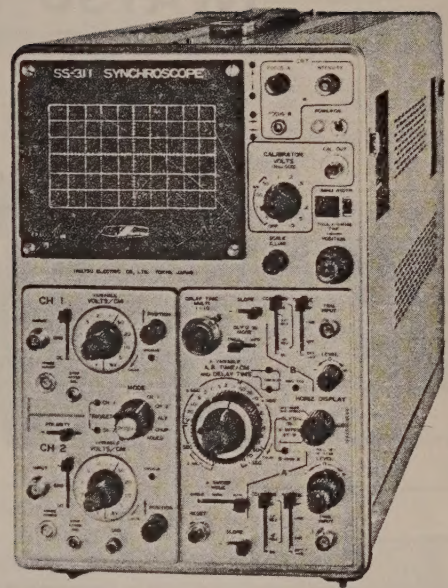


SS-311

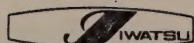
IWATSU



INSTRUCTION MANUAL

SYNCHROSCOPE SS-311

Serial Number _____



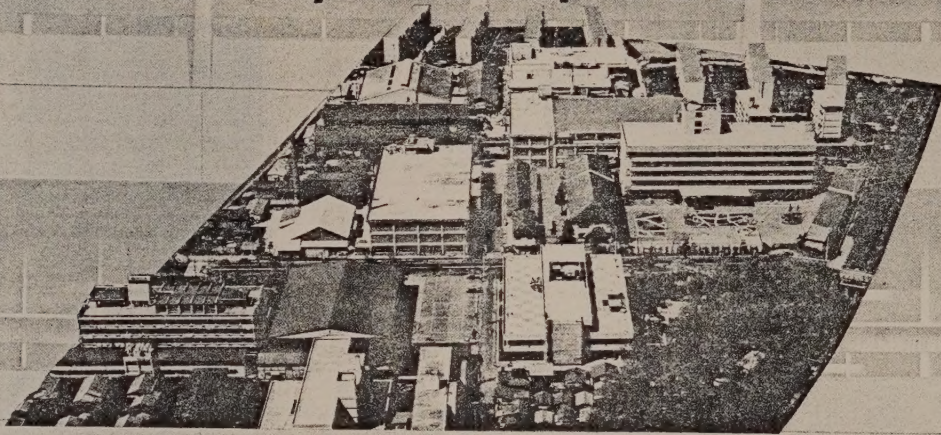
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Thank you for your purchasing IWATSU Synchroscope SS-3 | |



NOTICE

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While all procedures described herein have been verified by IWATSU/E-H, minor errors in translation may exist. In such event, please IWATSU/E-H.

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Circuit Arrangement Diagrams

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Schematic Diagram

General

The SS-311 SYNCHROSCOPE is a wide bandwidth, all purpose synchroscope. Its bandwidth ranges from DC up to 300 MHz.

Maximum deflection sensitivity of the electronically switched dual-trace vertical deflection system is 5 mV/cm, and the super-wide bandwidth 300 MHz, is held up to the 10 mV/cm range.

The horizontal deflection system contains a trigger circuit which can be triggered from DC up to 300 MHz, and delayed sweep circuit which allows magnified observation of any desired point on the displayed waveform. The 5 inch square CRT with an internally marked graticule provides a 60 mm (Y axis) x 100 mm (X axis) parallax-free display.

Extremely high stability is obtained by the use of a completely solid-state circuit. Measurements can be performed only 15 seconds after switching the power on. This compact and light weight instrument ensures accurate measurements anytime and anywhere.

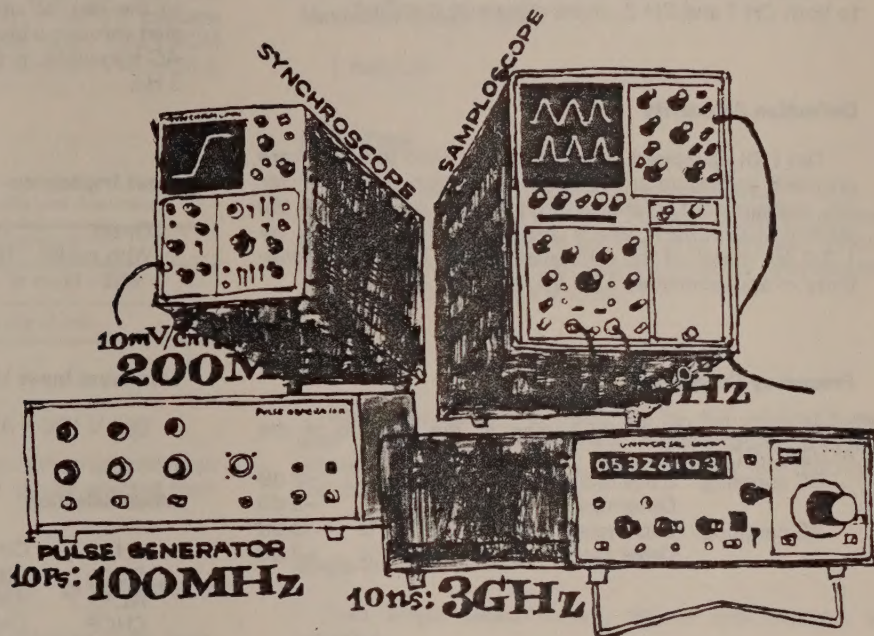
Composition

The instrument is composed of the following articles.

Accessories

Coaxial cable (BB-500)	1
Jumper cable (TT-400-G)	1
Probe (1022)	2 sets
2000 Earth Lead	1
Post Adapter (C)	2
Fuse (3 A)	2
Hexagonal Wrench (4 mm)	1
Hexagonal Wrench (3 mm)	1
Hexagonal Wrench (No. 2-UNC)	1
Screw Driver	1
Polarized Filter	1
Dust Cover	1
Accessory Container	1
Instruction Manual	1
Inspection Report	1

CHAPTER 1 CHARACTERISTICS



In this chapter, the electrical and environmental conditions necessary to assure accurate measurements are described briefly. Refer to "Description of Panel Controls" in Chapter 2, for information on the controls and connectors mentioned in the chapter.

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► Vertical Deflection System

The pre-amplifier of the vertical deflection system is an electronically switched dual-trace system. The characteristics and accuracy in the following description are applicable to both CH 1 and CH 2, unless otherwise specified.

Deflection Sensitivity

Ten (10) calibrated ranges from 5 mV/cm to 5 V/cm are provided to ensure an optimum deflection sensitivity for any measurement. Variable attenuation is possible with the VARIABLE control which decreases the sensitivity by 1/2.5 (or more) of the calibrated value. Thus a low sensitivity of approximately 12.5 V/cm.

Frequency Bandwidth

The bandwidth corresponding to the position of the AC-GND-DC switch is:

DC coupling	5 mV range	DC — 250 MHz	—3 dB
	Other ranges	DC — 300 MHz	—3 dB
AC coupling	5 mV range	3 Hz — 250 MHz	—3 dB
	Other ranges	3 Hz — 300 MHz	—3 dB

Rise Time

5 mV range	1.4 nsec (nsec = 10^{-9} second)
Other range	1.2 nsec

Frequency Bandwidth

50 MHz range	DC — 50 MHz (rise time 7 nsec)	—3 dB
FULL range	DC — 300 MHz	—3 dB

Square Wave Characteristics

The square wave characteristics differ somewhat depending on the position of the VOLTS/CM switch as shown in the following. The values shown are for an input square wave with a rise time of less than 300 psec.

VOLTS/CM switch in 5 mV, 10 mV position		Other positions	
Overshoot	3 % or less	Overshoot	5 % or less
Undershoot	2 % or less	Undershoot	3 % or less
Ringing	3 % or less	Ringing	2 % or less
Sag (at 1 MHz)	1 % or less	Sag (at 1 MHz)	1 % or less
Sag (at 60 Hz)	1 % or less	Sag (at 60 Hz)	1 % or less

Signal Delay Time

Approximately 80 nsec.

Input Signal Coupling Mode

Three (3) coupling modes, AC, DC and GND (to identify the ground potential on display) are available.

In the DC position, the input signal is coupled directly to the vertical amplifier and in the AC position, it is coupled through a blocking capacitor. Attenuation for the low AC frequency in the AC position is 3 dB at approximately 3 Hz.

Input Impedance

Direct	1 megohm	shunted by 14 pF
With probe	10 megohm	shunted by 10 pF or less (10 : 1)

Maximum Input Voltage

500 V (DC + AC peak or AC peak to peak)

Mode Selection

CH 1	CH 1 only
CH 2	CH 2 only
ALT.	Alternate sweep of CH 1 and CH 2
CHOP	Chopped switching (at approx. 1 MHz) of CH 1 and CH 2
ADDED	CH 1 ± CH 2

Polarity Inversion

The polarity of the CH 2 display can be switched to NORM (normal) or INV (inverted).

Common Mode Rejection Ratio

In the ADDED (CH 1 — CH 2) mode, CH 1 and CH 2 form a sort of differential input circuit. The common mode rejection ratio (CMRR) in this mode is more than 20 : 1 (for an input signal of 10 MHz).

Linearity

When a signal displayed at the center of the CRT with a vertical amplitude of 20 mm is moved to the top or bottom of the horizontal graticule scale, the variation in the vertical amplitude of the display is within ±2 % (±0.4 mm).

Drift

The drift, or vertical shift of a display with time is:
 5 mm/hour — 5 mV range
 3 mm/hour — other range
 (When measured 15 minutes after the power is applied.)

CH 2 OUT Signal

The input signal fed to the CH 2 input is amplified by five and is available at the CH 2 OUT terminal. The performance shown in Table 1-1 is obtained when the CH 2 OUT is connected to the CH 1 INPUT (cascade connection of CH 1 and CH 2), and both VOLTS/CM switches are in the 5 mV/cm positions with the VARIABLE control in the CALIB position.

Table 1-1

Item	Performance and Accuracy
Sensitivity	1 mV/cm $\pm 3\%$
Bandwidth	DC - 30 MHz -3 dB
Noise	5 mm p-p or less

Internal Trigger Selection

To ensure stable triggering in internally triggered dual-trace measurements, the trigger signal can be selected from either CH 1 or CH 2.

► Horizontal Deflection System

The horizontal deflection system provides three functions.

Main sweep	(A sweep)
Delayed sweep	(B sweep)
External sweep	(XY scope)

A Sweep Time (A TIME/CM)

Twenty-seven (27) calibrated sweep times from 10 nsec/cm to 5 sec/cm are available. Continuous variation of the sweep time is also possible by using the A VARIABLE control which reduces the rated sweep time by 1/2.5 times (or more). The slowest sweep time is 12.5 sec/cm (or more).

The accuracy of each sweep time with the VARIABLE control in the CALIB position is within $\pm 3\%$ of the rated value.

B Sweep Time (B TIME/CM)

Twenty-four (24) calibrated sweep times from 10 nsec/cm to 0.5 sec/cm the B TIME/CM VARIABLE control on the right side parallel functions similar to the A VARIABLE.

The accuracy of each TIME/CM position with the B TIME/CM VARIABLE control in the CALIB position is within $\pm 3\%$ of the rated value.

Sweep Linearity

The linearity of both the A and B sweeps at any position of the TIME/CM switch is within $\pm 3\%$ of the rated value.

Sweep Magnifier

The display can be magnified horizontally by 10 times.

Maximum Sweep Time

1 nsec/cm

Delay Time

A continuously variable sweep delay from 1 μ sec to 50 sec is available and by using the A VARIABLE control, the delay can be extended up to approx. 125 sec. When a calibrated delay time is not required, a delay time between 20 nsec and 0.5 usec is available.

Delay Jitter

When the display is magnified by the delayed sweep, jitter is caused on the display. The amount of jitter is within 20000 : 1 which is determined by the ratio of A and B TIME/CM range.

Single Sweep

Two single sweep modes, normal and delayed, are available.

External Sweep

In order to sweep the horizontal axis with an external signal, the external signal may be fed to the CH 2 INPUT terminal of the vertical deflection circuit.

Performance is shown in Table 1-2.

Table 1-2

Item	Performance and Accuracy
Input Impedance	1 megohm shunted by 14 pF
Deflection Sensitivity	5 mV/cm - 5 V/cm (within $\pm 3\%$ of rated value of CH 2 VOLTS/CM switch when variable is positioned at CALIB) Continuously varied from 5 mV/cm to 12.5 V/cm with VARIABLE
Frequency Bandwidth	DC - 4 MHz within -3 dB
Bandwidth applicable to phase measurement	DC - 2 MHz (phase difference at 2 MHz : 3° or less)

► Triggering

Individual triggering is provided for each sweep; the A triggering for the A sweep and B triggering for the B sweep.

— A Triggering —

Type of Trigger Signal Source

4 positions Internal (INT)
 External (EXT, $\text{EXT} \div 10$)
 Power Source (LINE)

Maximum Input Voltage ± 5 V (SOURCE switched to EXT)
 ± 50 V (SOURCE switched to $\text{EXT} \div 10$)
 Maximum Peak Voltage 500 V (dc + ac peak or ac peak to peak)

Triggering Frequency Range and Trigger Level

The triggering frequency range and level are shown in Table 1–3.

Auto and Normal Trigger Mode

The A SWEEP MODE switch is used to select AUTO or NORMAL triggering mode of the A SWEEP. In the AUTO mode, the sweep circuit will not be triggered by signals below 50 Hz even if the COUPLING switch is set in the DC position. When a trigger signal is not present, the sweep will freerun. In the NORMAL trigger mode, the sweep can be triggered from DC. When a trigger signal is not present, only a spot will appear on the CRT.

— B Triggering —

Trigger Signal Sources

Any one of four (4) triggering signal sources, i.e. INT, EXT, $\text{EXT} \div 10$, and LINE can be selected.

Trigger Input Coupling Mode

Modes: AC, LF REJ, HF REJ, and DC
 Triggerable frequency range of each mode is shown in Table 1–3.

Input Impedance and Maximum Input, Peak Voltage of External Trigger Signal Input Connector (TRIG INPUT)

Input Impedance 1 megohm shunted by 20 pF or less

Table 1–3 Triggerable Frequency Range and Level of A Triggering

A SWEEP MODE	COUPLING	Triggerable Frequency Range	Trigger Level	
			Internal Trigger (display amplitude)	External Trigger (voltage)
NORM and AUTO	DC	DC — 20 MHz	4 mm or more	0.1 Vp-p or more
		20 MHz — 50 MHz	10 "	0.15 "
		50 MHz — 100 MHz	15 "	0.2 "
		100 MHz — 150 MHz	20 "	0.25 "
		150 MHz — 200 MHz	25 "	0.3 "
		200 MHz — 300 MHz	30 "	0.35 "
		300 MHz — 500 MHz		0.4 "
	AC	30 Hz — 20 MHz	4 mm or more	0.1 Vp-p or more
		20 MHz — 50 MHz	10 "	0.15 "
		50 MHz — 100 MHz	15 "	0.2 "
		100 MHz — 150 MHz	20 "	0.25 "
		150 MHz — 200 MHz	25 "	0.3 "
		200 MHz — 300 MHz	30 "	0.35 "
		300 MHz — 500 MHz		0.4 "
	LF REJ	50 kHz — 20 MHz	4 mm or more	0.1 Vp-p or more
		20 MHz — 50 MHz	10 "	0.15 "
		50 MHz — 100 MHz	15 "	0.2 "
		100 MHz — 150 MHz	20 "	0.25 "
		150 MHz — 200 MHz	25 "	0.3 "
		200 MHz — 300 MHz	30 "	0.35 "
		300 MHz — 500 MHz		0.4 "
	HF REJ	30 Hz — 10 kHz	4 mm or more	0.1 Vp-p or more

Note: In the AUTO mode, input signals below 50 Hz will not trigger the sweep circuit even if the COUPLING switch is set to the DC position.

Slope

- + (Sweep is triggered by the positive going slope of the input signal), and
- (Sweep is triggered by the negative going slope of the input signal).

Trigger Signal Input Coupling Mode

Four types of trigger coupling modes are available: AC, LF REJ, HF REJ, and DC. The triggering frequency range of each mode is shown in Table 1-4.

Input Impedance and Maximum Input, Peak Voltage of the External Trigger Signal Input Connector (TRIG INPUT).

Input Impedance	1 megohm shunted by 20 pF or less
Maximum Input Voltage	±5 V (SOURCE switched to "EXT") ±50 V (SOURCE switched to "EXT ÷ 10")
Maximum Peak Voltage	500 V (dc + ac peak or ac peak to peak)

Triggering Frequency Range and Trigger Level

The triggering frequency range and level are shown in Table 1-4.

► Signal Outputs**A GATE**

Positive square wave synchronized with A SWEEP, amplitude approx. 5 V p-p with a load of 100 kilohms or more.

Output resistance : 330 ohms

B GATE

Positive square wave synchronized with B SWEEP, amplitude approx. 5 V p-p with a load of 100 kilohms or more.

Output resistance : 330 ohms

► Calibrator

The calibration voltage is obtained from the CAL OUT connector. Characteristics of this output are shown in Table 1-5.

Table 1-5

Item	Characteristics and Accuracy	
Voltage	Square wave	5 mVp-p to 10 Vp-p in 11 steps, within ±2 %
Frequency	1 kHz ± 1 % or less	
Duty Ratio	49 : 51 or less	
Rise and Fall Time	Rise time	0.1 μsec or less
	Fall time	0.5 μsec or less

Calibration Current

The square wave current described in Table 1-6, flows through the current calibrator loop in the direction indicated by the arrow.

Table 1-6 Calibration Current Characteristics

Item	Characteristics and Accuracy	
Current	Square wave	5 mA p-p, within ±2 %
Frequency	1 kHz, within ± 1 %	

Table 1-4 Triggerable Frequency Range and Level of B Triggering

DLY'D (B) MODE	COUPLING	Triggerable Frequency Range	Trigger Level	
			Internal Trigger (display amplitude)	External Trigger (voltage)
TRIG'D	DC	DC - 20 MHz 20 MHz - 50 MHz 50 MHz - 100 MHz	4 mm or more	0.1 Vp-p or more
			10 "	0.15 "
			20 "	0.2 "
	AC	30 Hz - 20 MHz 20 MHz - 50 MHz 50 MHz - 100 MHz	4 mm or more	0.1 Vp-p or more
			10 "	0.15 "
			20 "	0.2 "
	LF REJ	50 kHz - 20 MHz 20 MHz - 50 MHz 50 MHz - 100 MHz	4 mm or more	0.1 Vp-p or more
			10 "	0.15 "
			20 "	0.2 "
	HF REJ	30 Hz - 10 kHz	4 mm or more	0.1 Vp-p or more

► Cathode Ray Tube Circuit

Cathode Ray Tube (CRT)

Type D13–500 GH/01, 5-inch rectangular type, parallax free, internally marked graticule.
Effective
Display Area 60 mm (vertical) x 100 mm (horizontal)

Acceleration Voltage

Approximately 15 kV

External Intensity Modulation

Minimum INT. MOD.
VOLTAGE: +4 – +15 V
Z AXIS INPUT
Input Impedance: 15 kilohms shunted by 30 pF or less

► Power Requirements

Operating Range

By selecting an appropriate position of the LINE VOLTAGE switch located the rear panel, this instrument can be used with the line voltages (commercial power sources) shown in Table 1–7.

(This model is normally supplied for use on 100 V sources. However, it can be modified easily for 200 V use when requested.)

Table 1–7 Operating Voltage

Source Voltage	Switch Position	Applicable Line Voltage Range
100 V	100 V	90 – 110 V
	115 V	105 – 126 V
200 V	200 V	180 – 220 V
	230 V	207 – 253 V

Line Frequency

50/60 Hz

Power Consumption

Approx. 150 W (at 100 V)

► Environmental Conditions

Temperature Range

The environmental temperature range for normal operation of this instrument is from –10°C to +50°C.

Humidity Range (Relative Humidity)

This instrument operates normally with a relative humidity of up to 90 % at 40°C.

Vibration

This instrument will operate normally after a vibration test wherein the instrument is subjected to vibrations with an amplitude of 1.5 mm peak-to-peak at 1000 cycles per minute along each of the three major axes for one hour.

Shock

Operation of this instrument is normal after three shock tests for each major axis.

This can be performed by raising one edge of the equipment 5 cm above a rigid test bed (or, an incline of 30° degrees, maximum) and releasing it.

► Construction

External Dimensions

Approx. 215 mmW x 305 mmH x 485 mmL

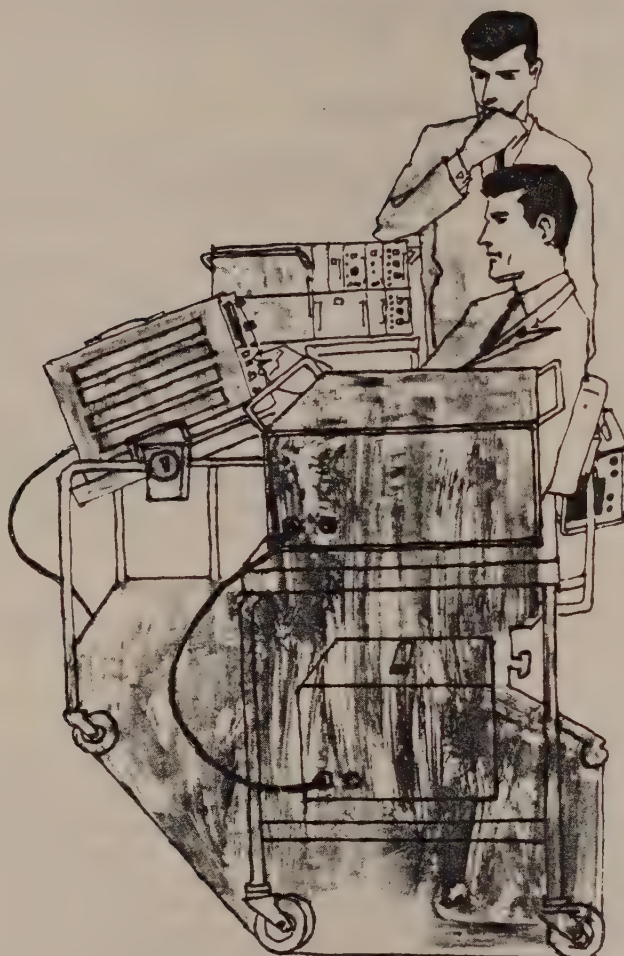
Weight

Approx. 20 kg

Color

Front panel White aluminum
Cabinet Munsell notation 5GY5/0.5 leather grain

CHAPTER 2 OPERATION



For effective use of this instrument, the operator must be familiar with the functions and operation.

In this chapter, handling precautions and the functions of panel controls will be described. Practical operating procedures will be described in the latter half of this chapter.

When this instrument is to be used immediately, the first part of this chapter may be bypassed and the section "Operating Procedure" on page 2-00 referred to.

Handling Precautions	2- 2
Description of Panel Controls	2- 2
Operating Procedures	2- 7
Pre-start Operation	2- 7
Applying POWER and Obtaining a Sweep	2- 8
Applying Signal and Trigger	2- 8
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Cascade Connection	2-15
Sweep Magnification	2-15
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Single Sweep Operation	2-17
X-Y Scope Operation	2-18

▷ Handling Precautions

Panel Cover

A panel cover is provided to protect the front panel and is removed by unlocking the two spring fasteners.
By sure to install the cover over the front panel before transporting the instrument.

Optimum Observation Position of CRT

For convenient observation, the auxiliary stand on the bottom front of the equipment may be used to provide an optimum tilt angle.

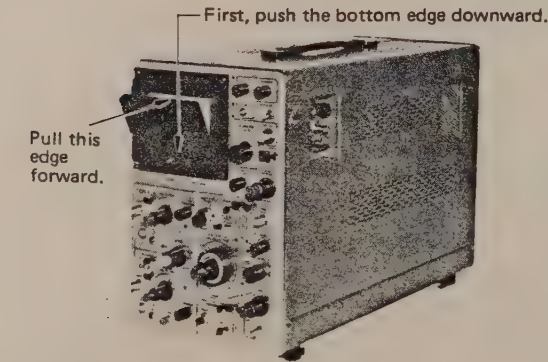
Filter

A mesh filter is used in this instrument, and a polarized filter is provided as an accessory. These filters are used for higher contrast of the trace to facilitate observation and to absorb the external light falling on the phosphor screen. Features of the individual filters are indicated in Table 2-1, and it is recommended that a suitable filter be selected in accordance with the situation.
When photographing a display, remove the filter to improve the definition as indicated in Fig. 2-2. Press the top and bottom edge of the filter, and the filter will be released and project from the frame. This filter is subject to damage and should therefore be handled carefully during removal or inspection.

Table 2-1

Polarized Filter	Mesh Filter
The external light diffusion is removed. However, the surface reflection remains. Good focusing can be obtained.	Surface reflection of light is eliminated since external light through the mesh can be completely absorbed. Sharpness of the trace focus is slightly deteriorated.

Fig. 2-2 Removal of Filter



► Description of Panel Controls

The function and/or purpose of switches, controls, and connectors on the front, right, and rear panels will be described. For concentric knobs, the red markings on the panel indicate the position of the red knob. Refer to Fig. 2-1 (folded page).

▷ Front Panel

— Power Supply and CRT Circuit —

POWER ON

Line switch. When turned to the ON position, power is supplied to the internal circuits and the pilot lamp lights.

SCALE ILLUM

Controls illumination of graticule. Lamps are intensified by clockwise rotation of this control, and go off at extreme counterclockwise position.



Indicates in which direction the trace lies when not near the center of the graticule.

INTENSITY

Controls brightness of trace or spot. The trace is intensified by clockwise rotation of this control, and de-intensified by counterclockwise rotation.

FOCUS A

A control to focus the trace or spot on the CRT when the brightness is changed by INTENSITY.

FOCUS B

An auxiliary control for FOCUS A, to focus the trace or spot on the CRT.

— Vertical Deflection System —

Corresponding controls and connectors for CH1 and CH 2 function identically, therefore these will be described collectively.

MODE (Gray knob)

Determines operating mode of dual trace vertical axis amplifier. The following modes are available.

CH 1

Selects CH 1 amplifier only. In this position, the instrument operates as a single trace synchroscope.

CH 2

Selects CH 2 amplifier only. The instrument also operates as a single trace synchroscope.

ALT

Operation of CH 1 and CH 2 is alternately switched after each horizontal sweep.

Simultaneous display of each signal becomes impossible at low sweep speeds (below approx. 2 msec/cm). The ALT mode is suitable for comparatively high frequency input signals.

Simultaneous single sweep measurement of two signals is impossible in the ALT mode.

CHOP

Signals from CH 1 and CH 2 amplifiers are switched at a repetition rate of approximately 1 MHz, and are simultaneously displayed.

In this mode, the signals are displayed as dotted lines, and signals may become inconvenient to observe at high sweep speeds of approximately 5 μ sec/cm or above. The CHOP mode operation is preferred for measuring comparatively low frequency signals.

ADDED

CH 1 and CH 2 amplifiers operate simultaneously, and the algebraic sum or difference of these signals is displayed.

PUSH (push switch)

Selects the internal trigger source in the MODE switch ALT, CHOP and ADDED positions. The trigger is alternately switched to CH 1 or CH 2 at each depression and the CH 1 or CH 2 trigger source is indicated by neon lamps to the left of the switch. When the trigger switch is in the CH 1 position a part of the input signal applied to the CH 1 INPUT jack is fed to the trigger circuit and when the trigger switch is in the CH 2 position, a part of the input signal applied to the INPUT of CH 2 is fed to the trigger circuit.

When the MODE switch is in the CH 1 or CH 2 position, the push switch has no function and the trigger signal is selected by the MODE switch. When the MODE switch is in the CH 1 position, a portion of the input signal applied to the INPUT connector of CH 1 is fed to the trigger circuit and when the MODE switch is in the CH 2 position, a part of the input signal applied to the INPUT of CH 2 is fed to the trigger circuit in the same way regardless of the setting of the trigger switch.

POLARITY

A switch to select the output polarity of CH 2. In the NORM position, a normal output is obtained, and in the INV position, the polarity is reversed.

INPUT

A BNC type connector to connect the signal to be

measured. When a probe is used for measurements, its output is connected to this connector.

PROBE POWER

When an optional source follower probe is used for measurement, power for the probe is supplied from this connector.

AC-GND-DC

A switch to select the input coupling mode.

In the AC position, the input signal is coupled to the vertical axis amplifier through a coupling capacitor. The DC component of the input signal is blocked and only the AC component is displayed.

In the DC position, the input signal is directly coupled to allow the display of all components, including the DC component of the input signal.

In the GND position, the input of the vertical axis amplifier is disconnected from the INPUT connector and grounded to aid in determining the ground potential of the display (This is normally used as a reference level for measurement.)

VOLTS/CM (Gray knob)

A switch to select vertical deflection sensitivity from 5 mV/cm to 5 V/cm in 10 steps. An appropriate position must be chosen for adequate display size.

When the VARIABLE control is turned fully clockwise (CALIB), the voltage per one division (1 cm) of the graticule is that indicated by the position of the VOLTS/CM switch.

VARIABLE (Red knob)

A continuously variable control to attenuate the input signal. The maximum attenuation ratio of 1/2.5 (or more) is obtained at the fully counterclockwise position of this control. Therefore, continuous attenuation between steps of the VOLTS/cm switch is possible.

For quantitative measurement of input signal, the VARIABLE control should be set to the CALIB position.

UNCALIB

Used as a warning light to bring to the operator's attention the fact that the VOLTS/CM vertical attenuation is no longer calibrated due to the VARIABLE control being out of the CALIB position.

STEP ATTEN BAL

Proper adjustment assures that the spot or trace does not shift up or down when the position of the vertical deflection sensitivity VOLTS/CM switch is switched from 10 mV to 5 mV. This screwdriver adjustment should be set in the 5 mV range to obtain the same vertical position as in the 10 mV range.

POSITION

A control to adjust the vertical position of the trace or spot. When this control is turned clockwise, the trace moves upward, and it moves down with counterclockwise rotation.

GND

Ground terminal

BANDWIDTH

Selects the bandwidth of the vertical deflection system. When set to the "FULL" position, the bandwidth is 300 MHz (250 MHz at 5 mV/cm sensitivity).

In the 50 MHz range, a lamp on the front panel is illuminated, and indicates that this switch is set to the 50 MHz range. The 50 MHz range. The 50 MHz range attenuates objectionable high-frequency noise. This range is used when the measurement frequency range is below within 50 MHz.

— Horizontal Deflection System —

HORIZ DISPLAY (Gray knob)

Selects one of the following four horizontal deflection modes:

A

A mode used for ordinary waveform measurement.

Horizontal trace is produced by a sawtooth wave generated in the A SWEEP GENERATOR. Sweep time is determined by the A TIME/CM switch and A VARIABLE control.

Triggering of this sweep mode is controlled by the controls located on the lower right section of the front panel (enclosed in thick line "A").

A INTEN BY B

For ease of delayed sweep observation [a selected portion of the input signal is magnified in the delayed sweep, and this function is described in the following paragraph DLY'D (B)], the portion of the A sweep which is swept by the B sweep is intensified more than the normal A sweep. (Refer to "Operating Procedure, Delayed Sweep Operation" for details of this function.)

DLY'D (B)

In this mode, the sweep is delayed, and the intensified part of the display obtained above (A INTEN BY B) is magnified in the horizontal display area.

Refer to the section "Delayed Sweep Operation" for details of this function.

Triggering of this sweep mode is selected by the controls located at the center right of the front panel (enclosed by the thick line "B").

CH 1 VERT CH 2 HORIZ

The setting used for an external sweep (X-Y scope)

mode. The internal sawtooth generator is not used in this mode, and the horizontal sweep is provided by an external signal-fed to the "CH 2 INPUT" connector of the vertical deflection circuits.

A SWEEP MODE

This switch determines the operating mode of the A SWEEP circuit.

AUTO

The A SWEEP circuit is triggered in the AUTO trigger mode. In this mode, the triggering mode automatically change to free running when the input trigger frequency drops below 50 Hz; when a trigger signal is not present; or when the LEVEL control is set to a point which exceeds the trigger point — the point on input signal waveform from which the trigger pulse is initiated.

The triggering frequency range in this mode is from 50 Hz up to 300 MHz. AUTO used in conjunction with the (PULL HF) STABILITY —

The AUTO operation described above shows the conditions observed when the triggering circuit [(PULL HF) STABILITY control — red knob described later in this chapter] is depressed.

For triggering in the 300 — 500 MHz frequency range, refer to the paragraph [(PULL HF) STABILITY (red knob).]

NORM

The A SWEEP circuit is triggered in the Normal trigger mode. In this mode, the sweep stops and only a spot is present when a trigger signal is not applied. The same thing occurs when the LEVEL control exceeds the triggering point.

The triggerable frequency range is from DC to 300 MHz.

The description of the (PULL HF) STABILITY in the AUTO operation section above applies to the NORM mode.

SINGLE

Single sweep operation is performed. The horizontal deflection circuit is swept only once. Single sweep operation is possible only at the A, A INTEN BY B and DLY'D (B) positions of the HORIZ DISPLAY switch.

RESET

A pushbutton switch containing a lamp, which has the combined functions of a switch and an indicator. The following operations are provided by this switch.

(1) This pushbutton switch is used for the single sweep operation which initiates only one sweep and for the waiting state (waiting the trigger signal for single sweep).

(2) By pushing the RESET button while the HORIZONTAL DISPLAY switch is set to the A INTEN BY B or the DLY'D B position the A sweep part following the B sweep part will be deleted, and the display is greatly intensified. The increase of intensity depends on the selected delay time. The deletion of A sweep part is indicated by an indicator, B ENDS A. Further depression of the RESET button terminates the B ENDS A operation (the indicator goes off and the A sweep part is again displayed). Note that the B ENDS A operation is invalid in the A TIME/CM

range between 0.1 SEC and 0.5 SEC. In a manner similar to single-sweep operation, the indicator of the button shows that the sweep circuit is triggerable.

B ENDS A

Indicator which shows that the B ENDS A pushbutton is selected.

A, B TIME/CM & DELAY TIME (Gray knob)

The larger gray knob indicates the A TIME/CM range and DELAY TIME, and the smaller gray knob indicates the B TIME/CM range.

The A TIME/CM (DELAY TIME) control is used to select a sweep time from 10 nsec/cm to 5 sec/cm in 27 steps. The optimum position for an observation should be determined in accordance with the frequency and rise time (or fall time) of the input signal.

This switch also determines the delay time in delayed sweep operation.

When the VARIABLE control is turned fully clockwise (CALIB position — UNCAL light goes off), the sweep time can be read directly from the setting of the TIME/CM switch. The delay time can also be read directly by setting the A VARIABLE control to the extreme clockwise position and by multiplying the A TIME/CM setting and the DELAY TIME MULTI setting. It should be noted however, that the DELAY TIME MULTI indication becomes uncalibrated in the A TIME/CM switch ranges from 10 n SEC to 0.5 μ SEC. In these switch positions, the UNCALIB indicator lights to indicate that the sweep is not calibrated.

The B TIME/CM switch selects a sweep time from 10 nsec/cm to 0.5 sec/cm in 24 steps for the delayed sweep mode.

The sweep time in the delayed sweep mode can also be read directly from the panel indication by turning the B TIME/CM VARIABLE (located on the right side panel) control fully clockwise (CALIB position — the UNCALIB indicator goes off).

A VARIABLE (red knob)

A fine adjustment control for A sweep time. By adjusting this control, the sweep time indicated by the A TIME/CM switch can be extended by 2.5 times (or more). The sweep speed becomes slower with counterclockwise rotation of this control. For quantitative measurements, this control should be set to the CALIB position.

UNCALIB

Indicators to indicate that the sweep time or delay time are not calibrated.

The indicator lights in the following two cases and indicates that the A sweep or B sweep time is uncalibrated.

- (1) When the HORIZ DISPLAY switch is set to the A INTEN BY B position, and the A VARIABLE control is in a position other than CALIB.
- (2) When the HORIZ DISPLAY switch is set to the

DLY'D (B) position, and the B TIME/CM VARIABLE control is in a position other than CALIB.

Two lamps located in the lower section light in the following two cases to indicate that the delay time is not calibrated.

- (1) When the HORIZ DISPLAY switch is set to the A INTEN BY B or DLY'D (B) position, and the A TIME/CM switch is positioned in the range between 10 nsec to 0.5 μ sec.

- (2) When the HORIZ DISPLAY switch is set to the A INTEN BY B or DLY'D (B) position, and the A VARIABLE control is in a position other than CALIB.

DLY'D (B) MODE

A switch to select the delay sweep mode, effective only when the HORIZ DISPLAY switch is set to the A INTEN BY B or the DLY'D (B) position.

In the AUTO position, the delayed sweep becomes a non-triggered mode, and in the TRIG'D position, the delayed sweep is triggered.

DELAY TIME MULTI

This control continuously varies the delay time, and the desired portion of the input signal can be partially magnified in the display area.

POSITION (gray knob)

Used to adjust the horizontal position of the trace or spot. Clockwise rotation of this control moves the trace to the right, and counterclockwise rotation shifts the trace to the left.

(PULL X10 MAG) FINE (red knob)

A push-pull switch and fine position control. As position control, used for fine adjustment of horizontal positioning. As a push-pull switch, used for magnifying sweep time 10 times (by pulling). The fine control is particularly effective for positioning of the magnified horizontal display.

— Trigger Circuit —

Switches and connectors in the trigger circuit are classified into those related to the A sweep (grouped and enclosed in the thick line marked A — lower right section of the front panel) and those for the B sweep (enclosed in thick line marked B, right center section of the front panel), however, the function of the corresponding controls in the two circuits is practically identical.

The following descriptions, therefore, are for the controls and connectors of the A sweep unless otherwise specified.

SOURCE

Selects one of the following trigger signal sources. Refer to "Operation, Proper Triggering" for details.

INT

Sweep is internally triggered by the input signal fed to the INPUT connector.

LINE

Sweep is triggered by line frequency. The line frequency signal is fed to the trigger circuit.

EXT

Sweep is externally triggered. The input signal, or a signal of which the timing is a multiple of the input signal, must be connected to the TRIG INPUT connector.

EXT ÷ 10

The external trigger signal is attenuated by 10 : 1 in this position. This is advantageous when the external trigger signal is excessively large and the proper triggering point cannot be obtained in the EXT mode. This position can also be used to attenuate the external sweep input signal by 10 : 1.

TRIG INPUT

A connector for connecting an external trigger signal.

COUPLING

To ensure stable triggering, a specified type of external trigger signal coupling to the trigger circuit is selected depending on the trigger signals. (Refer to "Proper Triggering Operation" for detail.

AC

Trigger signal is AC coupled. Since the DC component of the trigger signal is blocked, influence of the DC voltage on the trigger signal is eliminated.

LF REJ

External trigger signal is connected to the trigger circuit through a high-pass filter. Low-frequency noise superimposed on the trigger signal or trigger signals lower than approx. 30 kHz are blocked.

HF REJ

External signal is connected to the trigger circuit through a low-pass filter. High-frequency noise trigger signal higher than approx. 10 kHz is blocked.

DC

The external trigger signal is coupled directly to the trigger circuit and the sweep can be triggered by a very low frequency, or dc.

SLOPE

Selects the slope of trigger signal which starts the sweep. The sweep can be triggered from the negative (—) or positive (+) going portion of the input signal.

LEVEL (gray knob)

Selects the amplitude point on the trigger signal at which the sweep is triggered.

(PULL HF) STABILITY (red knob)

This control functions as a push-pull switch and a trigger level control for high frequency. For normal triggering, this control seats in the pushed state. If proper triggering is unobtainable for high-frequency trigger signals with the LEVEL control and the STABILITY control, pull the knob out. The circuit is set to HF trigger mode and jitter in the circuit is reduced. Adjust the LEVEL and STABILITY again.

When this knob is pulled out (HF triggering) and a trigger signal is not present, the sweep circuit enters the automatic sweep mode.

— Calibrator —

CALIBRATOR VOLTS

The switch selects the amplitude of the calibration voltage available at the CAL OUT connector. Calibration voltages from 5 mV to 10 V in 11 steps are provided. The calibration oscillator stops when this switch is turned to the OFF position.

CAL OUT

A connector to supply the calibration output voltage (frequency approximately 1 kHz) selected by the CALIBRATOR VOLTS. Output impedance is 50 Ω in the red marked range of the CALIBRATOR VOLTS switch, and becomes higher in the ranges above .5 V.

▷ Right Side Panel

CH 2 OUT

The input signal connected to CH 2 is amplified 5 times, and is available at this connector.

B TIME/CM VARIABLE

A fine adjustment for B sweep time.

This control extends the indicated sweep time of B TIME/CM, by 2.5 times (or more). With counterclockwise rotation of this control, the sweep speed is reduced. For quantitative measurement, this control should be set to the CALIB position.

A GATE

A square wave output of approx. 5 V p-p coincident with the A sweep is obtained at this connector. Output resistance is approximately 1 kilohm.

TRACE ROTATION

A screwdriver adjustment to align the trace with the horizontal graticule lines. This adjustment is provided to compensate for variations in the earth's magnetism.

B GATE

A square wave output of approx. 5 V p-p coincident with the B sweep is obtained at this connector. Output impedance is approximately 330 kilohms.

PROBE LOOP

A square wave of 1 kHz provides 5 mA of current which flows in the direction indicated by the arrow. This current is used for calibrating the current probe. The current waveform is picked up by clamping the clip of the probe over the loop.

▷ Rear Panel

Power Cable

A power cable for supplying power to the instrument.

100 V – 115 V Switch (Toggle Switch)

A switch to select the applicable power source voltage. In the 100 V position, this instrument operates on a source voltage of $100\text{ V} \pm 10\%$, and in the 115 V position, operates on $115\text{ V} \pm 10\%$.

By a simple change of wiring, this instrument can be operated on $200\text{ V} \pm 10\%$ or $230\text{ V} \pm 10\%$.

3A SLOW

A fuse holder containing a 3 amp slow blow fuse. The slow blow fuse will blow in the event excessive current is drawn during operation but will not blow as a result of a current surge when the POWER switch is turned ON.

Z AXIS INPUT

A connector for external intensity modulation. Input impedance is approximately 47 kilohms, and the maximum allowable voltage is 200 V p-p.

► Operating Procedure

The proper operating procedures for this instrument will be described next. The best way to become familiar with the operation of this instrument is to apply various input signals and operate the controls. The internal circuits will not be damaged by manipulation of the panel controls and switches. However, the precautions described in "Pre-start operation" should be observed.

► Pre-Start Operation

Check Source Voltage

Check the voltage of the power source. This instrument is designed to be used on the line voltages shown in Table 1–7. Set the LINE VOLTAGE RANGE switch to a position which coincides with the available line voltage. Operating this instrument on line voltages other than those listed in the table may cause trouble. If a suitable source voltage is not available an adequate transformer or regulator is required.

Ambient Temperature

The ambient temperature range for normal operation of this instrument is from -10°C to $+50^{\circ}\text{C}$. Avoid using this instrument in conditions exceeding this range.

Do not apply excessive input signals

The maximum allowable input voltage which can be applied to the CH 1 or CH 2 INPUT connectors is 500 V (dc + ac peak or ac peak-to-peak). Avoid connecting any voltage in excess of these ratings.

Do not leave an intensified spot stationary for long periods

Excessive intensity of a spot or trace, especially when left in one place for a long period, may damage the phosphor on the CRT, or other related parts.

Do not use excessive force on the switches or controls

Faulty manipulation of switches and/or controls will not damage the internal circuits, but rough handling of these controls may mechanically damage them.

▷ Applying POWER and Obtaining a Sweep

Now you are ready to proceed with actual operation.

Turn the POWER on and intensify the spot

Turn the POWER switch to the lower position (OFF) and insert the power cable plug into the line output. Place the following controls in the positions indicated below.

INTENSITY	Fully clockwise
MODE	CH 1
POLARITY (CH 2)	NORM
AC-GND-DC	GND
POSITION (Vertical)	Approximately center of range
HORIZ DISPLAY	A
(Pull x 10 MAG)	Pushed
A SWEEP MODE	NORM
A SWEEP SOURCE	INT
POSITION (Horizontal)	Approximately center of range
(PULL HF)	Pushed

Turn the POWER switch ON. The instrument is operational 15 seconds after it is turned on.

Turn the POSITION (horizontal) control clockwise slowly until the spot appears in the viewing area. The spot should be excessively bright. Turn the INTENSITY control counterclockwise until the desired intensity is obtained.

Focus the spot

Adjust the vertical POSITION control and the horizontal POSITION control alternately to move the spot to the center of the viewing area and place the following controls in the positions indicated below:

BANDWIDTH	50 MHz
VOLTS/CM (CH 1)	10 mV or below
VARIABLE (CH 1)	Fully counterclockwise

Focus the spot in the sequence as follows:

- (1) Reduce the spot intensity so that it is just visible.
- (2) Set the FOCUS A control to its center position.
- (3) Adjust the FOCUS B control to focus the spot.
- (4) Increase the spot intensity and adjust the FOCUS A control. If you cannot obtain a sharp focus, adjust the FOCUS B control again. Then, proper focus can be obtained by adjusting FOCUS A.
- (5) Repeat procedure (4) in the intensified or de-intensified conditions.

It is recommended that an input signal be connected to the instrument before focusing, since the input signal waveform may be slightly out of focus at the right and left edges of the viewing area, even though the spot is focused at the center.

Set the controls as follows so that a sharp display will be obtained. Use coaxial cables for connecting the input signals to eliminate the external noise.

BANDWIDTH	50 MHz
VOLTS/CM	10 mV or less
VARIABLE	Fully counterclockwise

SWEEP

When the A SWEEP MODE switch is changed to the AUTO position, the sweep should start. The sweep may become somewhat unstable at the mid-position of the LEVEL control. This is not a defect and the sweep will be stabilized by turning the control slightly to the right or left.

The INTENSITY may have to be readjusted for adequate trace intensity. With the controls set as instructed above, the trace starts from the center of the CRT and sweeps to the right. Turn the horizontal POSITION control counterclockwise to move the sweep start to the left edge of the graticule. Turn the A TIME/CM switch and the A VARIABLE control and confirm that the sweep time varies in accordance with the controls.

▷ Applying Signal and Trigger

Bandwidth

When the vertical frequency range selected is within 50 MHz, set the BANDWIDTH to the 50 MHz position and if a higher frequency range is required, set it to the FULL position. In the former case, less HF noise is generated and is thus convenient for operation.

Connect Input Signal

The next step is a practice operation to display a waveform. Connect the CAL OUT connector to CH 1 INPUT connector by using a BNC connection cable, and place the following controls in the positions indicated.

VOLTS/CM (CH 1)	.2
VARIABLE (CH 1)	CALIB position
CALIBRATOR VOLTS	.5

Change the AC-GND-DC switch to the DC position, and set the A TIME/CM switch to the 2 mSEC position. The calibration voltage should be displayed as a square wave approximately 2.5 cm in amplitude.

Turn the VOLTS/CM switch counterclockwise through its steps. The vertical amplitude should decrease in accordance with the steps. Confirm that the amplitude continuously decreases with counterclockwise rotation of the VARIABLE control.

Return the VARIABLE control to the CALIB position, and set the CALIBRATOR VOLTS to the 5 V position. The display amplitude should return to 2.5 cm. Through these operations, the relationship between the input signal, VOLTS/CM switch, and VARIABLE control should be clear.

Before Triggering

Proper triggering is a key point in operating a synchroscope. In general, the following items must be predetermined prior to triggering the sweep.

- (1) Selection of trigger mode
Internal trigger (INT), external trigger (EXT, or EXT $\div 10$), or line trigger (LINE).
- (2) Selection of trigger signal coupling mode
AC coupling, LF REJ, HF REJ, or DC
- (3) Selection of trigger slope
Trigger on positive (+) or negative (−) going slope of input signal. (Refer to the section on "Proper Triggering"

for details.)

In this practice operation, the sweep will be triggered in the AC coupled, internal trigger (INT) mode and triggered by the positive going slope of the input signal. Therefore, the trigger controls must be set as follows:

SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+

PROPER TRIGGERING



SOURCE

For stable display of the input signal waveforms, the sweep circuit must be triggered by the input signal, or a signal which is an integral multiple or submultiple of the input signal with regard to time, — this signal is called the trigger signal.

The trigger signal is fed to the trigger circuit where the trigger pulse is generated, and the trigger pulse then triggers the sweep circuit. The triggering method where the SOURCE switch is set to the INT position and a portion of the input signal to be measured is internally (from the vertical deflection amplifier) fed to the trigger circuit, is called the internal trigger method (refer to Fig. 2-3). The external trigger method requires the connection of an external signal, having a direct time relationship to the input signal as the triggering signal for the trigger circuit.

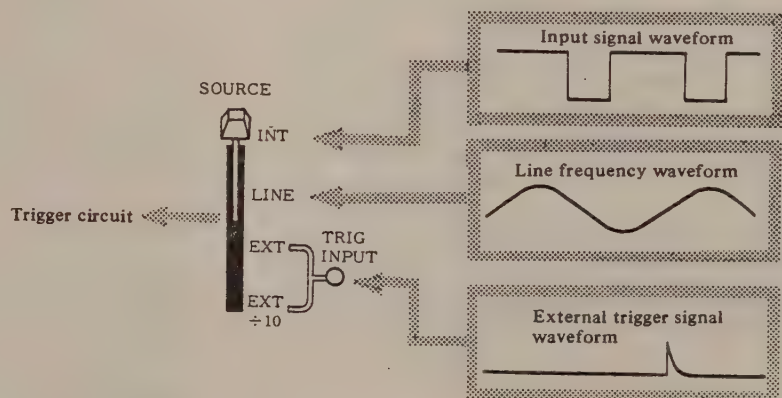
In this mode, the SOURCE switch must be set to the EXT or EXT $\div$ 10 position. For LINE trigger, the SOURCE switch is set to the LINE position, and the line voltage frequency signal is fed to the trigger circuit.

Internal Trigger In the internal trigger mode, the trigger signal is obtained internally from the vertical deflection amplifier, and even an input signal of very low amplitude is appropriately amplified to an adequate level for triggering. Therefore, control operation for this mode is very simple, and the chance that the comparatively low input impedance of the external trigger circuit may load the trigger signal source output is eliminated. From these advantages, it can be seen that internal triggering is generally convenient for measurement.

External Trigger The shortcomings of external triggering are described under internal trigger operation. However, the external trigger operation still provides the following advantages.

First, the triggering circuit is not influenced by the vertical deflection system. For example, the voltage level of the signal, which is fed to the trigger input in the internal trigger mode, varies when the position of the VOLTS/CM switch is changed.

Fig. 2-3 Selection of Trigger Signal with SOURCE Switch



PROPER TRIGGERING

These variations may necessitate readjustment of the LEVEL control every time the position of the VOLTS/CM switch is changed. Conversely, in the external trigger mode, the triggering is stable, once adjusted, regardless of variations in the vertical deflection system, except in the cases where the external trigger signal also varies.

Second, when it is desired to start the sweep a certain period in advance or after a certain time delay to display a particular point on the waveform, and provided that an appropriate triggering signal is available, the external triggering mode facilitates stable observation of the particular point.

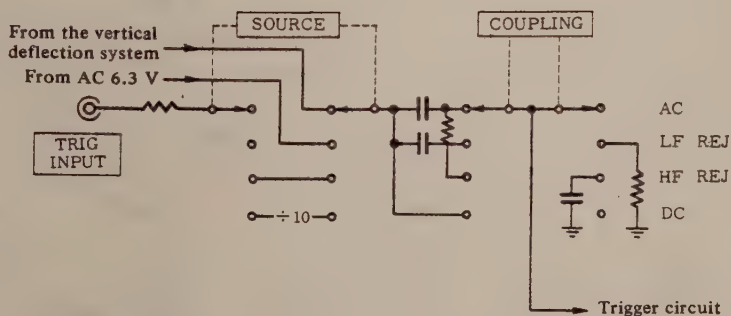
This external trigger signal should be connected to the TRIG INPUT. When the SOURCE switch is set to the EXT position, and the amplitude of the external trigger signal is excessively large, proper adjustment of the trigger level with the LEVEL control may be impossible. In these cases, trigger adjustment is facilitated by changing the SOURCE switch to the EXT $\div 10$ position which attenuates the trigger signal.

Line Trigger In the LINE trigger position of the SOURCE switch, the line voltage frequency is obtained directly from the power transformer, and the sweep circuit is stably triggered, neither influenced by the vertical deflection system as in the INT trigger mode, nor requiring complicated operation as in the EXT trigger mode.

Use Proper COUPLING

The COUPLING switch is to select the coupling mode of the trigger signal and the trigger circuit. Four coupling modes — AC, LF REJ, HF REJ, and DC — are available. In these modes, the trigger signal and the trigger input are connected by a capacitor (AC), a high pass filter (LF REJ), a low pass filter (HF REJ), and directly (DC). The switch facilitates the selection of a suitable coupling method to provide stable triggering in accordance with the type of trigger signal (dc, ac waveform, ac waveform superimposed on dc, and low or high frequency noise on a waveform).

Fig. 2-4



PROPER TRIGGERING

AC As shown in Fig. 2-4, the trigger signal is connected to the trigger circuit through capacitor coupling. The dc component in the trigger signal is blocked and only the ac component is used for triggering. This ensures stable triggering by eliminating the influence of the dc component.

The ac coupling is convenient for conventional measurement purposes, however triggering sensitivity decreases at low frequencies (below 30 Hz) and triggering becomes less stable.

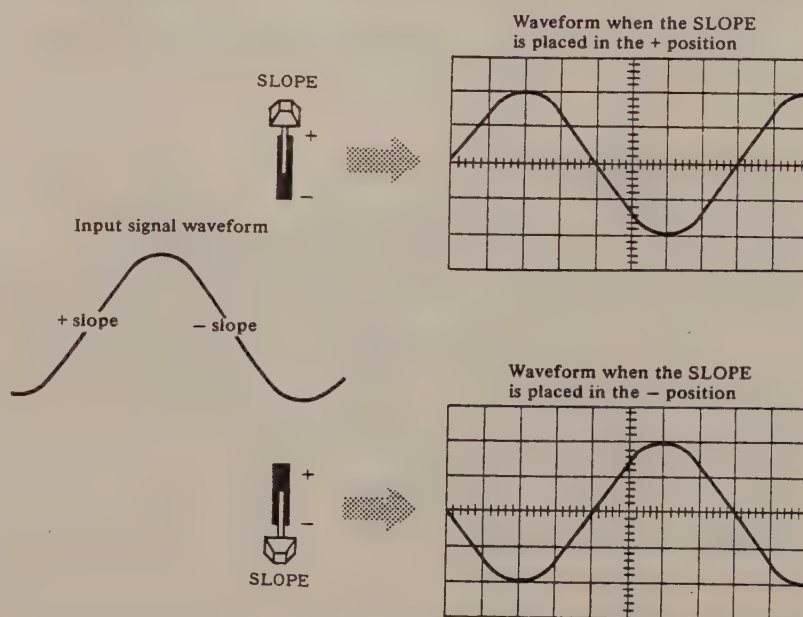
LF REJ In this position, the trigger signal is fed to the trigger circuit through a high pass filter (refer to Fig. 2-4) which blocks low frequencies (below approximately 30 kHz) or low frequency noise components superimposed on the trigger signal. Thus only the high frequency trigger signal triggers the sweep circuit. This mode is used to provide stable triggering when measuring signals containing low frequency noise components like that shown in Fig. 2-5.

HF REJ In this position, the trigger signal is fed to the trigger circuit through a low-pass filter, as shown in Fig. 2-4. Contrary to the LF REJ position, high frequency signals (above approximately 10 kHz), or high frequency noise superimposed on the trigger signal as shown in Fig. 2-5, is bypassed.

Fig. 2-5



Fig. 2-6 SLOPE



PROPER TRIGGERING



This coupling mode is convenient when using a trigger signal containing high frequency noise.

DC As shown in Fig. 2-4, the trigger signal is connected directly to the trigger circuit in this position which enables triggering from a varying dc signal.

If an external trigger signal superimposed on a dc voltage is fed to the trigger input in the dc coupling mode, and the dc level exceeds the control range of the LEVEL control 30, the trigger signal cannot trigger the sweep circuit. ac coupling must be used in this case.

Selection of TRIGGER

When the MODE switch is set to the ALTER, CHOP, or ADDED position in the INT trigger mode, the TRIGGER switch selects the trigger signal source. When the TRIGGER switch is placed in the CH 1 position, the CH 1 input signal is fed to the trigger circuit, and in the CH 2 position, the trigger signal is supplied from CH 2. Each channel desired is selected alternatively by PUSH switch and lamp indicates the selection.

Therefore, if two signals of the same frequency are being measured simultaneously by CH 1 and CH 2, the TRIGGER switch should be set to the channel having the higher input level and least superimposed noise. When the frequency of the input signals fed to the two channels is different, the sweep circuit should be triggered by the channel having the lower frequency. Otherwise, the lower frequency signal will not be displayed.

(Refer to Chapter 3 "Phase Measurement" for details.)

When the MODE switch is set to either CH 1 or CH 2, the TRIGGER switch is inactivated, and the display is triggered by the channel selected by the MODE switch. In other words, if the MODE switch is placed in the CH 1 position, the trigger circuit is triggered by the CH 1 input signal regardless of the position of the trigger switch.

Eliminating Jitter with STABILITY Control

When the sweep is triggered by a signal higher than approx. 10 MHz, jitter may remain in the display even if the trigger LEVEL control is set to the optimum point. This jitter can be eliminated by adjusting the STABILITY control.

This jitter may cause a double or triple display of an input signal at comparatively low frequencies of the trigger signal and synchronization will be lost at high frequencies of the same.

Triggering Method (AUTO Trigger)

The preceding control settings enable triggering by only adjusting the LEVEL control (A). Turn the LEVEL control (A) slowly; the display should be triggered stably at approximately the mid-position of the control. Vary the SLOPE switch (A) and adjust the LEVEL (A) control as shown in Fig. 2-7. The relationship between these controls and the display will be obvious.

Fig. 2-7 shows an example of a sine wave, but the triggering point can be selected in the same manner for a square wave. A high sweep speed which provides a magnified display of the leading or trailing edge will aid in the observation of the trigger point. The variable range of the trigger point is from 10 to 90 % of the slope height. (for and internally triggered sine wave of approx. 1 kHz with a vertical amplitude of 6 cm on the graticule — the triggering range in the external trigger mode differs with the external trigger signal level).

Turn the CH 1 VOLTS/CM switch counterclockwise to reduce the display amplitude by approximately 2 mm. This decrease of display amplitude decreases the trigger signal level, and the triggering may be lost and the display may start free-running. Adjust the LEVEL control (A) again until the display is stable.

In the AUTO trigger mode, the display will free-run when the triggering signal is not present, or when the LEVEL control (A) is not set at the triggering point. Therefore, when a free-running sweep is desirable, for example, to confirm the vertical position of the ground potential (which is the reference level of the vertical display), the AUTO position of the A SWEEP MODE is advantageous. It should be noted that the display will not be triggered in the AUTO mode by input trigger signals lower than 50 Hz. The triggered mode should be used for triggering such low frequency signals.

Triggering Method (NORMAL Trigger)

When the A SWEEP MODE switch is placed in the NORM position, the NORMAL trigger is used for triggering the sweep. The LEVEL control (A) must be adjusted

similarly in this mode.

In this mode, however, when the trigger signal is not present, or the position of the LEVEL control (A) exceeds the triggering point, the sweep stops, and the display becomes a spot awaiting triggering (the spot may not be visible unless it is intensified by adjusting the INTENSITY control).

The preceding triggering operations are based on the internal triggering mode, however, these operations are identical for LINE or EXTERNAL triggering, except for the operation of the input trigger signal source.

► Dual Trace Operation and Addition or Subtraction of Two Signals

Dual Trace Operation

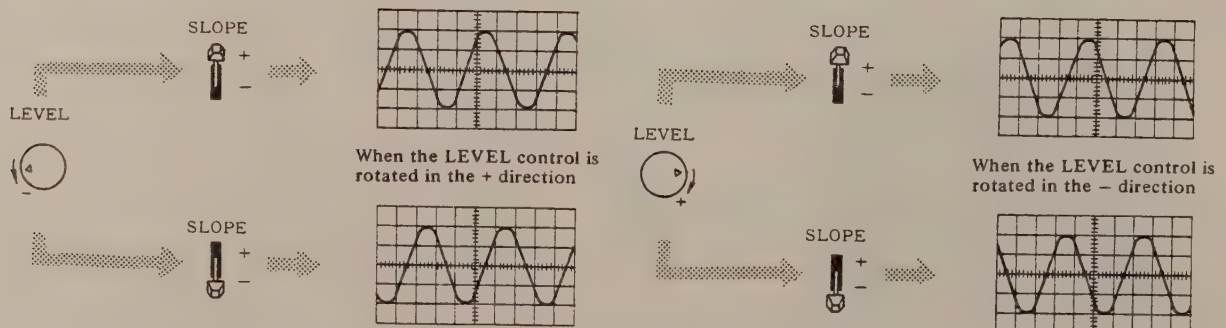
First, place the MODE switch in the ALT position. If the previously described control settings are retained, the calibrator output waveform is displayed as the CH 1 output and a trace (horizontal line) should appear as the CH 2 output. Both the CH 1 and CH 2 POSITION controls should be set to mid-range.

Set the AC-GND-DC switch of CH 2 to the DC position. Feed the CALIB OUT voltage to the CH 2 INPUT by using an appropriate BNC cable. A dual trace display is now present.

When the A TIME/CM switch is turned counterclockwise, the CH 1 and CH 2 outputs will be alternately displayed and simultaneous observation of the two displays becomes impossible. Dual trace measurement of low frequency signals which require slow sweep speeds of less than 2 msec/cm should be carried out in the CHOP mode as described below.

When the MODE switch is changed to the CHOP position, dual trace measurement at slow sweep speeds is possible. Contrary to the ALT mode it is inconvenient to observe at sweep speeds above $5 \mu\text{sec/cm}$ as the waveforms will be displayed as dotted lines. Dual trace measurements of high frequency signals which require sweep speeds higher than $5 \mu\text{sec/cm}$ or dual trace measurement of fast rise (or

Fig. 2-7 SLOPE and LEVEL



fall) time signals should be performed in the ALT mode.

When dual trace measurement of different frequency signals (these signals must have a direct time relationship) is required, the TRIGGER switch must be properly set as previously described in "Proper Triggering." More stable triggering will be obtained in the CHOP mode by setting the COUPLING switch in the HF REJ position.

Sum or Difference of Two Signals

When the CH 2 POLARITY switch is changed to the NORM position, and the MODE switch placed in the ADDED position, the sum or difference of the CH 1 and CH 2 signals, will be displayed. When the CH 2 POLARITY switch is changed to the INV position, the polarity of the CH 2 signal's inverted and added to the CH 1 signal. The difference between the two signals, or CH 1 + (–CH 2), is displayed.

In the ADDED position, the vertical position of the resultant waveform can be varied by either POSITION control, however, for accurate measurement, both POSITION controls should be set to midposition.

▷ Cascade Connection

By cascading the two amplifiers, the vertical deflection sensitivity can be increased to 1 mV/cm.

The cascade connection will be described using the calibration voltage as the input signal. Connect the CAL OUT to the CH 2 INPUT with the coaxial cable provided. Place the following controls in the positions indicated.

MODE	CH 2
VOLTS/CM (CH 1 · CH 2)	5 mV
VARIABLE (CH 1 · CH 2)	CALIB
CALIBRATOR VOLTS	5 mV

Trigger the sweep properly. The vertical amplitude of the display should be 1 cm which is the normal deflection sensitivity.

Connect the CH 1 INPUT to the CH 2 OUTPUT (located on the forward right side panel of the equipment) with the other coaxial cable. Change the MODE switch to the CH 1 position. The vertical amplitude of the display will become 5 cm, and the vertical deflection sensitivity is now 1 mV/cm.

In the cascade connection, noise increases to some extent result in a thicker trace (rated maximum trace width is 5 mm or less), in which case BAND WIDTH switch is used in 50 MHz range. Triggering may become slightly unstable, but can be stabilized by setting the COUPLING switch to the HF REJ position.

▷ Sweep Magnification

When a magnified display, with regard to time, of a particular part of a waveform is desired, the sweep speed may be increased. However, magnification by increasing sweep speed may drive the desired part out of the viewing area, unless the part is very close to the starting point of the sweep.

By placing the MAG switch in the x10 position, the center portion of the display is magnified by 10 times, as shown in Fig. 2–8. The trace length in the viewing area is

approximately 10 cm, however, the unmagnified trace is now extended to 100 cm. The entire trace can be observed by rotating the POSITION and FINE controls.

The sweep time, when magnified, is 1/10 of the switch position indication, and the maximum sweep speed of 10 nsec/cm for an unmagnified trace, becomes $10 \text{ nsec/cm} \times 1/10 = 1 \text{ nsec/cm}$.

Magnification of the sweep with the MAG switch is advantageous to increase the maximum sweep speed, but it reduces sweep intensity and may cause confusion in calculating the time relation of the displayed waveform (the multiplication by 1/10 may be overlooked). It may be advisable not to use the magnified sweep except in the following cases.

- (1) To magnify a particular point on the waveform which is a considerable distance from the starting point of the sweep.
- (2) When a sweep speed higher than 10 nsec/cm is desired.

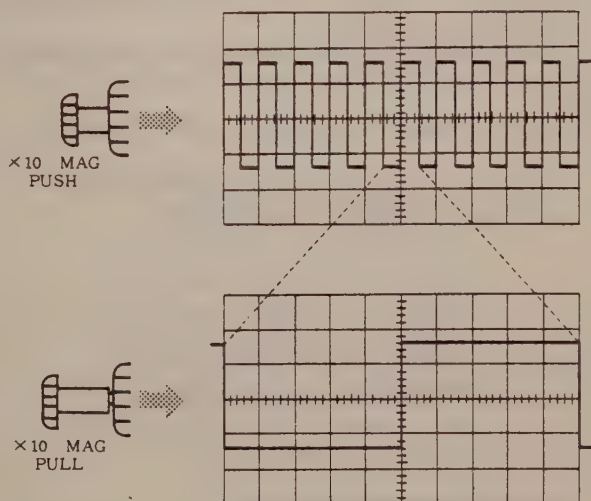
▷ Delayed Sweep Operation

Although sweep magnification with the MAG switch is simple to operate and magnifies the rated TIME/CM by exactly 10, its magnification is limited in value.

Magnification of the display by the delayed sweep can extend the magnification factor up to a value determined by a product of the A and B sweep times. This magnification factor, however, is limited by the frequency of the given input signal. In other words, when the input signal requires that the A TIME/CM switch be set to the position of 10 nsec/cm, no further magnification is possible. Magnification with the delayed sweep is advantageous in magnifying a selected portion of a comparatively low frequency signal.

The delayed sweep is classified into the non-triggered and triggered modes.

Fig. 2–8 Sweep Magnification with MAG Switch



Non-Triggered Delay Sweep

In the previous operations, various controls have been set to various positions. Now, for ease of delayed sweep operation, the following rearrangement of control settings is required.

MODE	CH 1
VOLTS/CM (CH 1)	.2
VARIABLE (CH 1)	CALIB
CALIBRATOR VOLTS	.5
HORIZ DISPLAY	A
A SWEEP MODE	AUTO or NORM
A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
DLY'D (B) MODE	AUTO
SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+
INTENSITY	Moderate spot brightness

Connect the CAL OUT connector to the CH 1 INPUT connector with a coaxial cable, and adjust the triggering for a stable display. Change the HORIZONTAL DISPLAY switch to the A INTEN BY B position, turn the locking lever of the DELAY TIME MULTI dial to the left to release the dial, and slowly turn the dial clockwise. A portion of the display (delayed sweep part) will be intensified, as shown in Fig. 2-9, and this intensified part will move toward the right with rotation of the dial. Any desired part of the A sweep display can be magnified in this manner. The width of the delayed sweep part is determined by the setting of the B TIME/CM switch and the B TIME/CM VARIABLE control (located on the right side panel).

Place the HORIZ DISPLAY switch in the DLY'D (B) position. The delayed sweep portion will be magnified to the full width of the viewing area, as shown in Fig. 2-10. The magnification ratio is determined by the ratio of the A sweep time to the B sweep time. The displayed waveform can be moved horizontally by rotating the DELAY TIME MULTI dial. This dial allows any desired portion of a displayed waveform to be magnified and observed. The delay time is determined by multiplying the readings of the A TIME/CM switch and the DELAY TIME MULTI dial (For direct calibrated readings, set the A VARIABLE control to the CALIB position).

Change the B TIME/CM switch to the $.2\mu\text{SEC}$ position, and turn the DELAY TIME MULTI dial slowly until the

leading or trailing edge of a square wave is displayed.

Delay jitter (unstable horizontal trace) will appear as shown in Fig. 2-11, and accurate evaluation of the leading or trailing edge will be difficult. This delay jitter restricts the upper limit of magnification. The magnification factor however can be increased by using the following trigger delay method.

Triggered Delay Sweep

Change the control settings as follows.

HORIZ DISPLAY	A INTEN BY B
A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
DLY'D (B) MODE	TRIG'D
SOURCE (B)	INT
COUPLING (B)	AC
SLOPE (B)	+

Turn the DELAY TIME MULTI dial more than one turn clockwise, and set the LEVEL (B) control to its mid-position. As shown in Fig. 2-12 the delayed sweep

Fig. 2-10 Magnification of Non-Triggered Delay Sweep

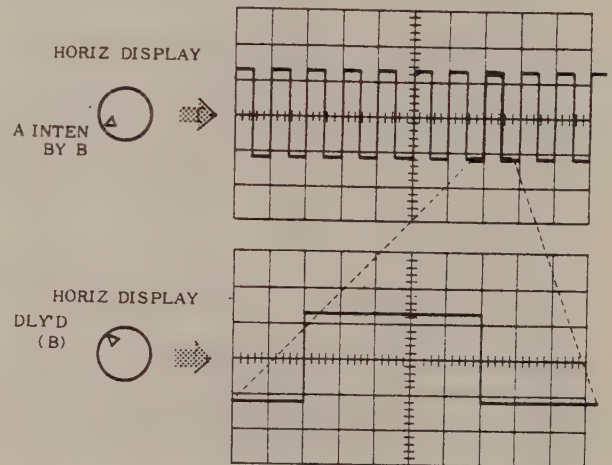


Fig. 2-11 Delay Jitter

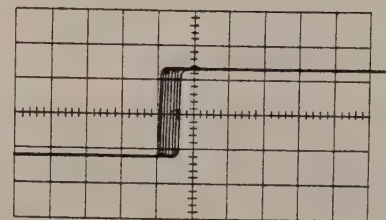
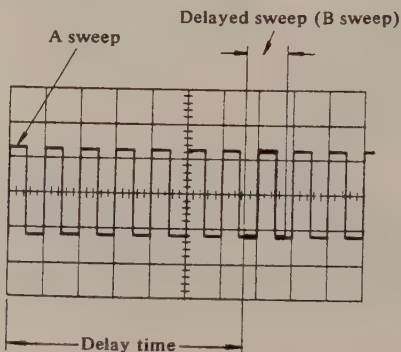


Fig. 2-9 Non-Triggered Delayed Sweep



part (intensified part) will be triggered at the start of the A sweep. When the DELAY TIME MULTI dial is turned clockwise, the delayed sweep part will jump sequentially from one square wave (A sweep) to the next. Change the SLOPE (B) switch to the negative (—) position. The delayed sweep part will now be triggered at the trailing edge of the A sweep waveform. The delayed sweep, in this trigger mode, starts at the same point on the A sweep each time. The width of the delayed sweep part is also determined by the B TIME/CM switch and the B TIME/CM VARIABLE control.

Change the HORIZ DISPLAY switch to the DLY'D (B)

Fig. 2-12 Triggered Delay Operation

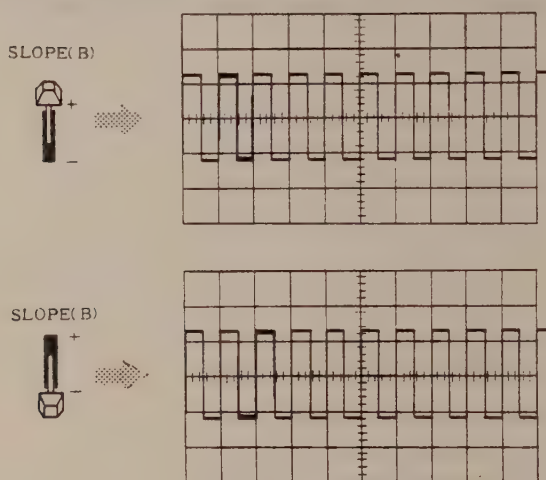
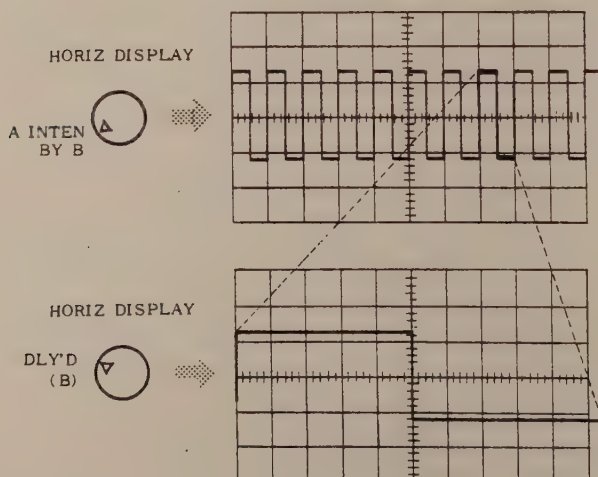


Fig. 2-13 Magnification in Triggered Delay Operation (SLOPE (B) switch + position)



position to magnify the delayed sweep part to the full width of the display as shown in Fig. 2-13. The magnification ratio is determined by the ratio of A sweep time to B sweep time. Change the B TIME/CM switch to the $.2\mu\text{SEC}$ position. Delay jitter should not appear. Therefore a higher magnification ratio can be obtained in this mode compared to that of the non-triggered mode. The magnified waveform does not move when the DELAY TIME MULTI dial is rotated. In this method, the displayed waveform is a part of the delayed sweep portion, and magnified with regard to time by the B TIME/CM switch.

▷ Single Sweep Operation

If a normal repetitive sweep is employed for observing a discharge waveform, chattering of relay contacts or other transient phenomena, the displayed waveform will appear to be out of sync as shown in Fig. 2-14. In such cases, the single sweep mode, by which the signal is swept only once, will display a correct waveform. Since the display is not repeated, the waveform is normally recorded by taking a photograph. (IWATSU can supply a universal camera mounting which can be used for any type of camera.)

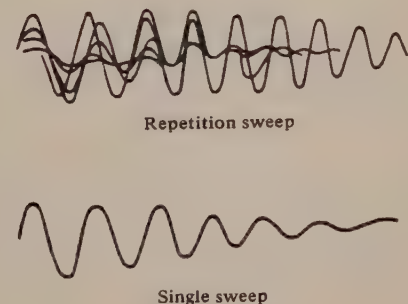
The single sweep operation will be explained by using the calibration signal. Connect the calibration voltage to the input, and set the controls as follows.

HORIZ DISPLAY	A
A SWEEP MODE	NORM
VOLTS/CM	Suitable position for adequate display height
A TIME/CM	Any position for appropriate display

Adjust the triggering for a stable display and then change the A SWEEP MODE switch to the SINGLE position. The waveform will be displayed only once each time the RESET button is pressed down.

Remove the calibration signal cable from the INPUT connector, and press the RESET button. The circuit is now reset and in a waiting condition (to actuate a single sweep when a trigger signal is applied), and a lamp in the push-button lights to indicate this status. By connecting the calibration signal to the input, a single sweep is

Fig. 2-14



actuated.

The waiting status may not be obtained when the LEVEL control is close to its mid-position. In this case, adjust the LEVEL control slightly. Simultaneous observation of dual trace waveforms is impossible in the single sweep mode.

Single-sweep operation can be accomplished, by using an external trigger. The trigger signal is applied to the TRIG INPUT jack from an external source and the external trigger signal operates in the same manner as that of a recurring input signal to the internal trigger.

▷ XY Scope Operation

The basic operating procedure for XY scope measurements will be described, using the calibration signal as the

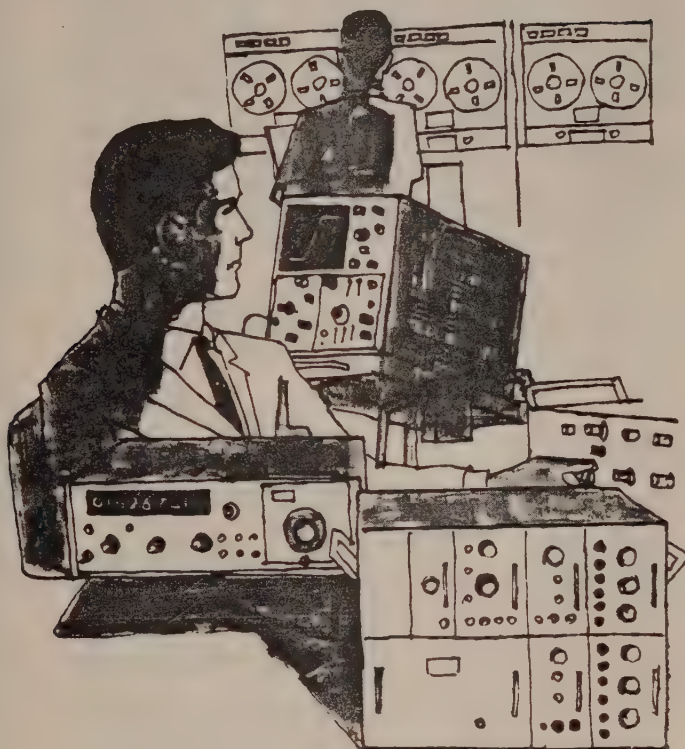
input. First, place the controls in the positions indicated below.

INTENSITY Fully clockwise
HORIZ DISPLAY CH 1 VERT CH 2 HORIZ

Turn the POSITION control counterclockwise until the spot appears. Connect the CAL OUT to both the CH 1 and the CH 2 inputs with an adequate cable. Set the VOLTS/CM switches of both CH 1 and CH 2 to the same range, and set the CALIBRATOR VOLTS switch to a position at which the output voltage will be two or four times that of the VOLTS/CM switch indication. Two spots will appear on a diagonal to the graticule. This is a Lissajous pattern for two square wave signals having a frequency ratio of 1 : 1 and the same phase.

By feeding sine wave inputs having different frequencies or different phase angles, various Lissajous patterns will be displayed. (Refer to phase measurement of Chapter—3.)

CHAPTER 3 MEASUREMENT



Various measurement procedures and their applications will be described in this chapter.

Refer to chapters 1 and 2 for technical characteristics and basic operating procedures of this instrument.

Connection of Input Signal . . .	3- 2
Proper Use of Probe	3- 4
Voltage Measurement	3- 4
Current Waveform Measurement	3- 5
Time Measurement	3- 6
Frequency Measurement	3- 8
Phase Measurement	3- 9
Measurement of Non-Electrical Phenomena	3-10

▷ Connection of Input Signal

The input circuit of this instrument, viewed from the INPUT connector, is composed of 1 megohm of resistance and 14 pF or parallel capacitance. When the accessory probe (type 1022) is used, the resistance increases to 10 megohms and the capacitance decreases to 10 pF or less, thus reducing the influence of the oscilloscope on the circuit to be measured.

The signal to be observed may be connected to this equipment with conventional insulated wire, shielded cable, or coaxial cable. The type of cable should be selected in accordance with the following conditions.

- Output impedance of signal source
 - Amplitude and frequency of signal
 - Presence of external noise
 - Distance between the instrument and signal source
- The preferable connection methods, classified in accordance with the type of input signal are shown in Table 3-1.

Table 3-1

Type of Input Signal		Distance	Connection Method				
			Insulated wire	Shielded wire	Probe	Coaxial cable	Others
Low Fre-quency	Low Imp.	Short	○	○	○		
		Long		○		○	
	High Imp.	Short		○	○		
		Long		○			
High Fre-quency	Low Imp.	Short			○	○	
		Long				○	
	High Imp.	Short			○	○	
		Long					○

The various connection methods will now be described further.

Connection Signal with Conventional Insulated Wire

Using conventional insulated wire is simple and does not attenuate the signal to be measured. The conductor can be connected to the INPUT connector by using the adapter (BNC-BP-12D) provided for this purpose.

However, if there is a considerable distance between the signal source and the oscilloscope and/or a magnetic field is present in the vicinity of the measuring cable, noise may be induced and affect the measurement. This induction is apparent when the impedance of the signal source is high.

Stray capacitance between a conventional insulated wire and ground is also considerable, and the input capacitance viewed from the signal source becomes: (stray capacitance Cs) + (instrument input capacitance Co). The influence of this method on the circuit to be measured is greater than that of the probe (attenuation ratio 10 : 1).

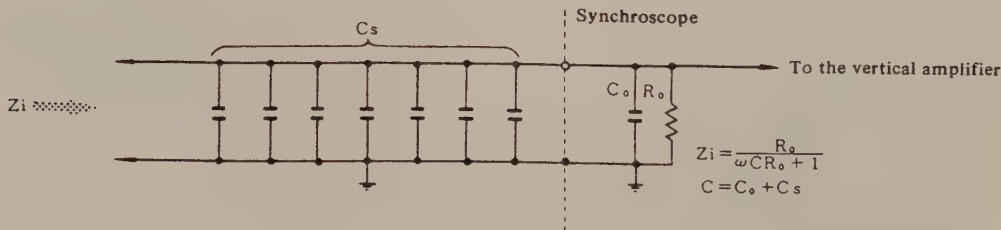
For example, assuming the output impedance of the signal source to be 1 kilohm with a frequency of 1 MHz and the input capacitance (stray capacitance of cable plus input capacitance of instrument) to be 100 pF, the signal source output is shunted by an equivalent resistance of 1.6 kilohms. At lower frequencies, the influence of the stray capacitance decreases. For example, the equivalent resistance of the cable becomes 1.6 megohms at 1 kHz and the influence on the signal source is reduced considerably.

The use of conventional wire is suitable mainly for low frequency low impedance measurements.

Use of Shielded Cables

The use of shielded cable protects the signal from extreme amounts of induced noise. However, the large capacitance of this cable (from 50 pF/m to 100 pF/m) limits its use at high frequencies. Shielded cable is advantageous to eliminate the influence of static induction.

Fig. 3-1 Input Impedance when Conventional Insulated Wire is Used.



Use of the Probe

When the accessory probe 1022 (attenuation ratio is 10 : 1) is used, the influence of external induction is also eliminated since the input cable is shielded as shown in Fig. 3-2. In addition, the wideband attenuator composed of attenuating resistor R_p , compensation capacitance C_p , the instrument input resistor R_o and stray capacitance C_o , ensures accuracy in measuring impedance or high frequency signal sources. Since the input capacitance of the probe (viewed from the probe tip) is approximately 10 pF (approx. 12 pF in Type 1023 probe), the input impedance of the probe is 15.6 kilohms (approx. 13 kilohms in Type 1023) and is comparatively higher than that in the previously described method.

However, the probe has some disadvantages as the input signal is attenuated by 1/10, and the cable length is restricted.

Use of Coaxial Cable

When the output impedance of a signal source is 50, 75, 93, or 125 ohms, the use of coaxial cable with the same characteristic impedance will enable high frequency signals to be coupled without attenuation.

It should be noted that the coaxial cable must be properly terminated at the instrument side to avoid distorting high frequency signals as shown in Fig. 3-3.

Other Method

For accurate measurement of remote signal sources having high frequency and high impedance, an impedance converter must be used to match the circuit impedance to that of the coaxial cable (75 ohms, for example) which is used to connect the signal to the instrument. A transformer may be used for a narrow bandwidth measurement, but a cathode follower or similar circuit is preferred for wide band measurement. (Refer to Fig. 3-4.)

When a high level signal is expected from the circuit to be measured, a voltage divider is used in conjunction with a load resistor R_o (shown in Fig. 3-5). R_o matches the characteristic impedance of the coaxial cable and also as part of the voltage divider.

Fig. 3-3 Signal Coupling Using Coaxial Cable

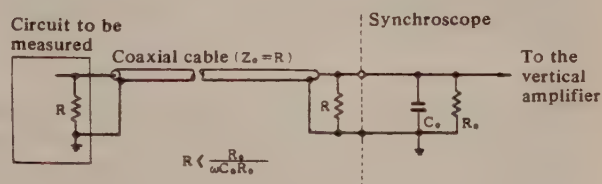


Fig. 3-2 Input Impedance When Probe is Used.

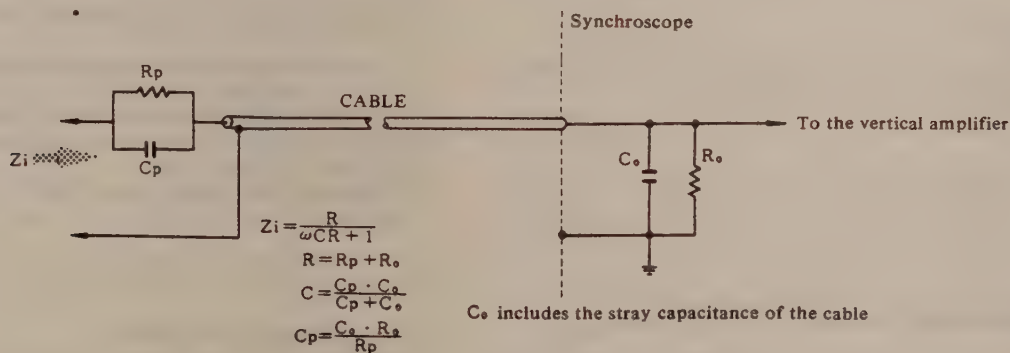


Fig. 3-4 Coupling a Remote Signal Source (1)

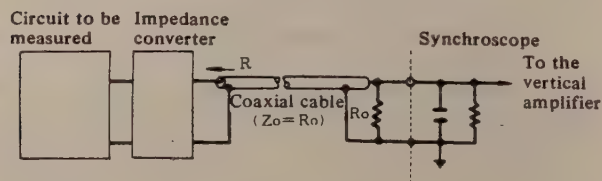
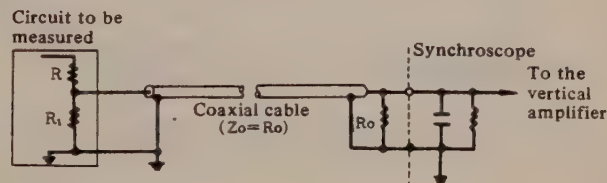


Fig. 3-5 Coupling a Remote Signal Source (2)



▷ Proper Use of Probe

A probe has many advantages, some of which are to eliminate external signal induction, to enable measurement with a higher input impedance than that of the signal source (measured signal), and to allow the tip to contact points in closely wired areas.

When using the probe, connect it to the instruments vertical deflection circuit INPUT terminal. A ground lead is provided through the probe and the ground clip should be attached to the ground of the circuit to be measured. The voltage value is calculated from equation 3-3.

Precautions on Use of the Probe

Withstanding voltage The maximum allowable probe input voltage is 500 V (dc + ac peak). Excessively large input voltage may cause break down of the probe.

Bayonet adapter If the probe ground lead is connected to the signal source ground when measuring a wave having a fast rise or fall time, it may cause ringing or other distortion in the displayed waveform. For measurements of this type, the bayonet adapter should be used to reduce the possibility of this type of distortion.

Probe Accessories

For effective use of the probe, various accessories are provided as shown in Table 3-2.

Fig. 3-6 Probe 1022

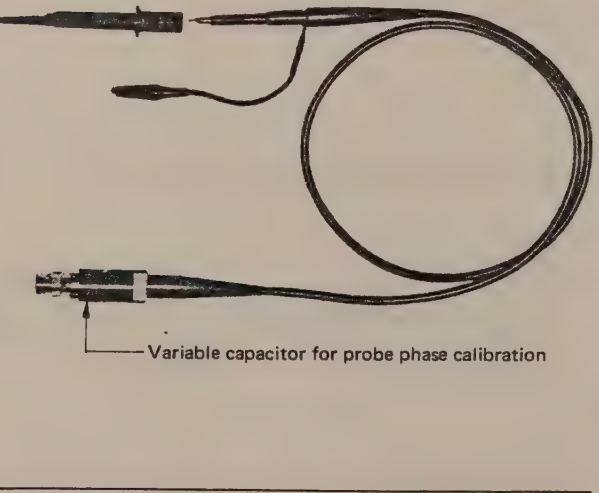


Table 3-2

Accessories	Purpose
Protection cap	Protects probe tip from damage when the probe is not being used.
Hook tip	Enables the probe to be hooked to the object to be measured.
Bayonet adapter	Used to connect the probe ground close to the point being measured. Prevents waveform distortion when measuring waveforms having fast rise or fall times.
Insulator tube	Prevents the probe tip from contacting circuits adjacent to the point being measured.
Probe hook	Used to fasten the probe head to the connector of the probe.

Probe Adjustment

For accurate measurement using a probe, the probe high frequency response phase and compensating circuit must be calibrated in accordance with the input impedance of the instrument.

The phase and compensating circuits for the HF response of the accessory probe are already initially matched to the instrument. Calibration, however, is required for accurate results. (Refer to Chapter 6, "Probe Adjustment.")

Precautions on Use of Source Follower Probe

The SFP-2 Source Follower Probe facilitates unattenuated (1 : 1) wide frequency range measurements.

If this probe is connected to the Synchroscope SS-311 while the power is ON, the low voltage supply circuit for the probe may be damaged.

Refer to "Instruction Manual for SFP-2" for details of the probe. The SFP-1 can not be used with the SS-311.

▷ Voltage Measurement

Quantitative Measurement

For direct reading of voltage values in quantitative measurement, the VARIABLE control must be set to the CALIB position. However, quantitative measurement of waveform amplitude is also possible with the VARIABLE control in a position other than CALIB.

(1) Determines the vertical amplitude of the display on the graticule.

(2) Connect the calibration voltage (CAL OUT) to the INPUT and adjust the CALIBRATOR VOLTS switch to obtain a display amplitude comparable to the previously displayed signal amplitude. Do not change the CALIBRATOR, position control, VOLTS/CM or the VARIABLE control. The vertical deflection sensitivity at these control positions is then calculated from the following equation.

Vertical deflection sensitivity (V/cm)

$$= \frac{\text{indication of CALIBRATOR VOLTS switch (V)}}{\text{displayed amplitude of CALIB voltage (cm)}} \dots\dots(3-1)$$

The signal amplitude is calculated from Equation 3-2 provided that the vertical deflection sensitivity is known from Equation 3-1.

$$\text{Input signal voltage (V)} = \text{vertical deflection sensitivity (V/cm)} \times \text{displayed amplitude (cm)} \dots\dots\dots(3-2)$$

DC Voltage Measurement

This instrument can also be used as a DC voltmeter. First, obtain a trace in the free-running mode and select a fast sweep time so that the trace will appear steady.

Turn the AC-GND-DC switch to the GND position, (vertical position of the trace now represents zero volts at the input as shown in Fig. 3-7). Adjust the vertical position to place the trace on a horizontal graticule line. Change the AC-GND-DC switch to the DC position, and observe the distance between the displayed signal level and the zero level line. This distance represents the value of the DC voltage.

If the signal level is displayed beyond the viewing area, reduce the vertical deflection sensitivity, and repeat the zero level setting and the input signal measurement.

When the signal level is displayed above the zero level, the polarity of the input signal is positive (+), and a negative (-) voltage is displayed below the zero level line. Letting the distance between the two lines represent A (cm), the input voltage can be calculated as in equation (3-3) or (3-4).

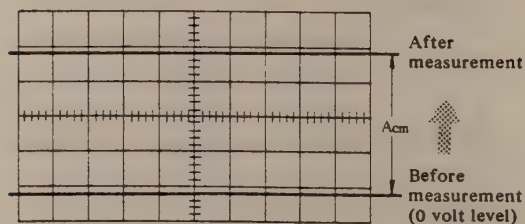
When the 10 : 1 probe is used for measurement:

$$\text{Voltage (V)} = \text{VOLTS/CM switch value (V/cm)} \times \text{displacement of trace level (A cm)} \dots\dots(3-3)$$

When the voltage to be measured is connected directly to the INPUT:

$$\text{Voltage (V)} = \text{VOLTS/CM switch value (V/cm)} \times \text{displacement of trace level (A cm)} \dots\dots(3-4)$$

Fig. 3-7 DC Voltage Measurement



AC Voltage Measurement

If an ac signal superimposed on a dc voltage with an amplitude larger than that of the ac signal is measured while the AC-GND-DC switch is in the DC position, the ac component may be displayed out of the viewing area. The ac waveform can be returned to the viewing area of the graticule by adjusting the POSITION control, but this may result in erroneous measurements. The ac portion may also be measured by reducing the vertical deflection sensitivity, but this reduces the accuracy of the measurement.

The AC position of the AC-GND-DC switch should be used for these purposes. By using the AC position, the DC component of the input signal is blocked by the coupling capacitor, and the AC portion can be displayed at an amplitude which provides sufficient measuring accuracy. The absolute value of the ac signal amplitude is calculated from equation (3-3) or (3-4).

(It should be noted that the displayed amplitude of an ac signal is attenuated by 3 dB at approx. 3 Hz in the AC mode. When the probe is used, the attenuation is 3 dB at approx. 0.3 Hz.)

The ac signal amplitude calculated from equation (3-3) or (3-4) represents the peak to peak value, and the effective value (Vrms) of a sine wave is found as

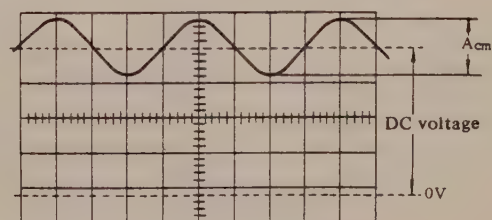
$$\text{Effective voltage (Vrms)} = \frac{\text{Volt (p-p)}}{2\sqrt{2}} \dots\dots\dots(3-5)$$

▷ Current Waveform Measurement

CRT oscilloscopes, including synchoscopes, display only the voltage of given signals. Electrical phenomena other than voltage, and mechanical vibrations or other physical phenomena must be converted into voltage variations before they can be measured.

Current can be measured by reading the voltage drop across a resistor of known value inserted in the circuit being measured. The current is then calculated with Ohm's law, $E = IR$. The value of a resistor inserted in the circuit must be sufficiently small so as not to change the characteristics of the circuit being measured.

Fig. 3-8 AC Signal Superimposed on DC Voltage



When a resistor cannot be inserted in the circuit, the current probe facilitates current measurement without disconnecting the circuit.

When the circuit being measured is isolated from ground, as shown in Fig. 3-9, correct current measurement with a conventional single input instrument is impossible. In other words, a differential amplifier is required.

As described in "Dual Trace Measurement and Sum or Difference of Two Frequencies" in Chapter 2, this instrument is provided with a differential measurement function.

For this function, set the MODE and CH 2 POLARITY to the ADDED and INV positions respectively, and connect the probe tips of the CH 1 and CH 2 inputs to the ends of resistor r . By setting the VOLTS/CM switches of CH 1 and CH 2 to an identical voltage range, the waveform across resistor r , or the current waveform, can be read directly.

▷ Time Measurement

Measurement of Time Interval

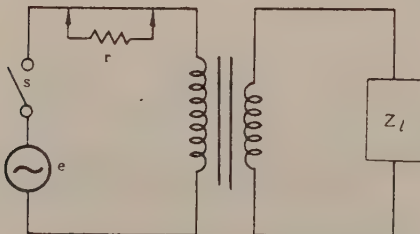
The time interval between two optional points on a waveform can be read directly by setting the VARIABLE control to the CALIB position and reading the horizontal distance between the points from the graticule.

Change the HORIZ DISPLAY switch to the A position, and set the A VARIABLE control to the CALIB position. Trigger the display and set the A TIME/CM switch to a position which facilitates reading of the distance. (See Fig. 3-10) The time interval (T) between the two points is calculated as:

$$\text{Time } T \text{ (sec)} = \text{TIME/CM switch value (sec/cm)} \times \text{distance between the points on the graticule (cm)} \times \text{reciprocal of MAG switch value} \dots\dots\dots (3-6)$$

The reciprocal of the MAG switch value is 1 when the display is not magnified and 0.1 when magnified.

Fig. 3-9



Difference of Time between Two Signals

The time difference between two signals is easily measured by using the ALT, CHOP, or ADDED mode of this instrument. Figs. 3-11 and 3-12 respectively show examples of these measurements.

In these modes, the display must be triggered by the leading signal with regard to time, or the TRIGGER switch must be set to the channel displaying the leading signal.

Read the distance T from the graticule, and calculate the time from equation (3-6).

Measurement of Leading (or Trailing) Edge of Waveform

The signal delay cable provided in the vertical amplifier facilitates internally triggered measurements of the rising (or falling) point of the leading edge of a waveform (shown in Fig. 3-13) as long as the rise (or fall) time of the waveform is faster than the signal delay time of 80 nsec.

When the rise (or fall) time of a waveform is slower than the signal delay time, the display must be externally triggered.

Fig. 3-10 Time Interval Measurement

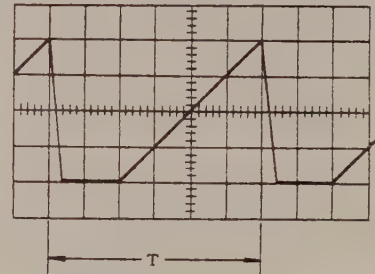
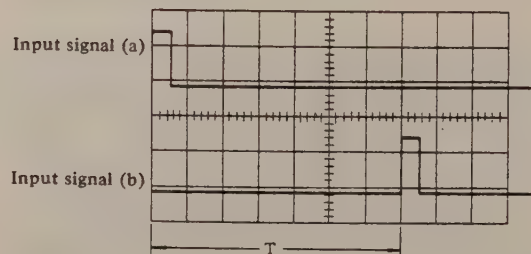


Fig. 3-11 Time Difference Measurement in ALT or CHOP Mode



Pulse Width Measurement

Pulse width is measured as follows.

Adjust the vertical position and amplitude of the display so that the pulse height is equal both above and below the center horizontal line of the graticule (set total height to 2 cm or 4 cm). Turn the VARIABLE control fully clockwise and set the TIME/CM switch to a position which allows easiest reading of the display. Read the distance between the centers of the leading and the trailing edges (T), (or cross points of these edges and the center horizontal line) from the scale on the horizontal graticule line. The pulse width is calculated from equation (3-6). Magnify the horizontal display if the pulse width is very narrow.

Fig. 3-12 Time Difference Measurement in ADDED Mode

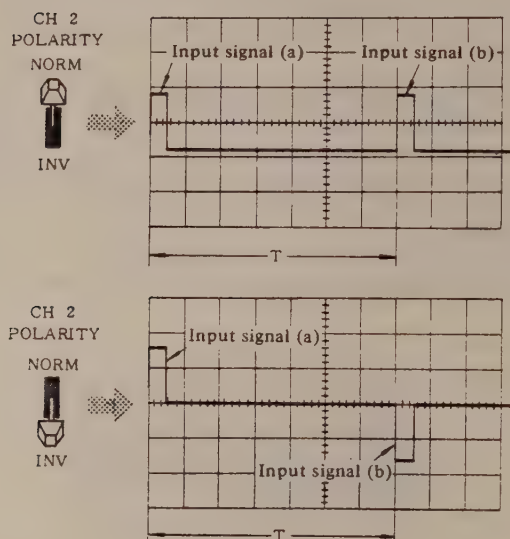
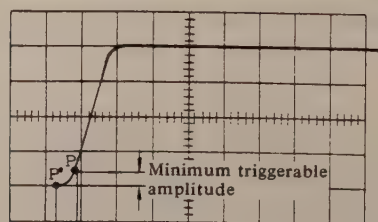


Fig. 3-13



Sweep starts at point P when signal delay cable is not provided.
Sweep starts at point P' when signal delay cable is provided.

Measurement of Rise (or Fall) Time of Pulse

Set the vertical and horizontal position and amplitude controls as in the pulse width measurement. Move the pulse display horizontally so that the upper 10% (4 mm in Fig. 3-15, since the pulse height is 4 cm) of the leading edge crosses the vertical center line of the graticule, and read the distance (T_1) between the point where the vertical leading (or trailing) edge of the pulse crosses the horizontal center line, and the vertical center line of the graticule. Adjust the POSITION control to move the lower 10% of the leading edge so it crosses the vertical center line. Read the distance T_2 . Substitute the value $T_1 + T_2$ in equation (3-6) to obtain the pulse width T (sec).

Direct reading of the pulse width is possible only when the rise (or fall) time of the pulse is sufficiently slower than the rise time of this instrument, i.e. 1.2 nsec. If a pulse having a very fast rise time is measured, the result (T) obtained from equation (3-6) must be corrected by the following equation (3-7).

$$T_r = \sqrt{T^2 - T_s^2} \quad (3-7)$$

T_r : True value of pulse width

T: Measured value

T_s : Rise time of this instrument (1.2 nsec)

Fig. 3-14 Pulse Width Measurement

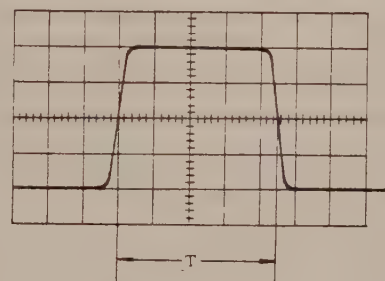
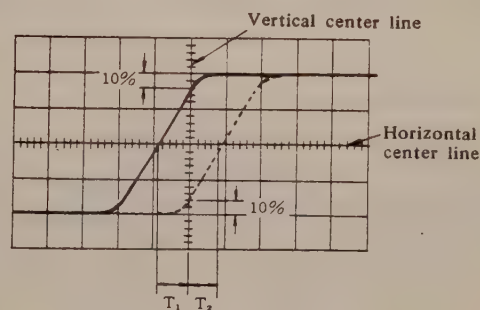


Fig. 3-15 Rise (or Fall) Time Measurement



▷ Frequency Measurement

Frequency measurements can be largely classified into three types.

First, the frequency can be calculated from the time per cycle (Equation 3-6) obtained as shown in Fig. 3-16, and Equation 3-8).

Frequency f (Hz) = $\frac{1}{\text{Time } T \text{ (sec)}}$ (3-8)

In Fig. 3-16, the length of one cycle is 8 cm and the TIME/CM switch is in the 1 μsec/cm position. Thus, the time T is,

T (sec) = 8 cm x 1 μsec/cm = 8 μsec

Therefore, the frequency f (Hz) is,

f (Hz) = $\frac{1}{8 \times 10^{-6} \text{ (sec)}}$ = 125 x 10³ (Hz) = 125 kHz

Second, the frequency can be calculated from equation 3-9 by counting the number of cycles (N) displayed in the horizontal scale (10 cm).

Frequency f (Hz) = $\frac{N}{\text{TIME/CM switch value} \times 10}$... (3-9)

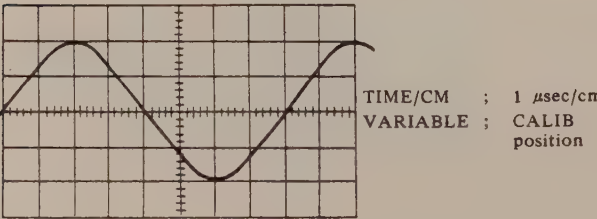
This method is more accurate than the former method, and absolute accuracy of measurement approaches that of sweep time, provided that the number of cycles, N, is sufficiently large (30 to 50). When N is comparatively small, reading the value of N below the decimal point becomes uncertain, and accuracy decreases.

These frequency measurement methods are based upon time measurement. When the frequency of the waveform to be measured is comparatively low (below 100 kHz) and its waveform is a simple sine, square, triangular, or saw-tooth, the frequency may be measured by using the instrument as an XY scope to display a Lissajous pattern, as described in Chapter 2.

Set the HORIZ DISPLAY to the CH 1 VERT CH 2 HORIZ positions. Feed the signal to be measured (assumed to be a sine wave signal) to the CH 1 INPUT, and connect the CH 2 INPUT to a signal source of a known frequency (calibrated signal generator). Set both the vertical and horizontal amplitudes to approximately 4 cm.

Vary the signal generator frequency to obtain a Lissajous pattern for a frequency ratio of 1 : 1, as shown in Fig.

Fig. 3-16 Frequency Measurement (1)



3-18. The Lissajous pattern for 1 : 1 is either a circle, ellipse, or a straight line. When the frequency ratio approaches 1 : 1, the pattern continuously varies from a → b → c → d → e → d → c → b → a, and repeats this variation. As the frequency ratio becomes closer to 1 : 1, the above variation subsides, and finally the pattern stops varying only and one of the waveforms will be displayed.

The signal generator frequency at which the pattern becomes stable represents the frequency of the signal being measured, and a frequency difference between them causes a deviation in the pattern and signifies a frequency deviation.

When the pattern variation (starts from a and returns to a) becomes slow enough to read, the number of variations per second represents the frequency difference.

A slight generator frequency change will clarify the difference as to whether low or high. This fact indicates that frequency measurement using a Lissajous pattern must be carried out for a sufficiently long period, particularly for low frequencies (1 Hz or 10 Hz, for example), to confirm that the pattern will remain stationary in this period.

Lissajous patterns for sine wave signals to be fed to the CH 1 - CH 2 INPUT having different frequency ratios are shown in Fig. 3-19. (The pattern for an optional frequency ratio may be determined by geometric drawings, however, the 1 : 1 pattern method using a variable frequency signal generator is the simplest and most accurate.

Fig. 3-17 Frequency Measurement (2)

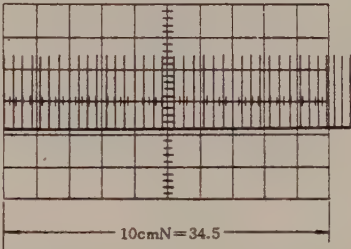
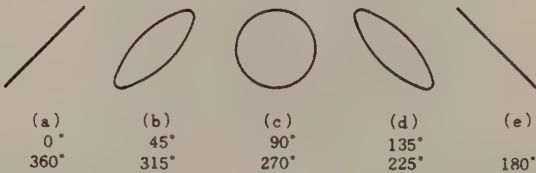


Fig. 3-18 Lissajous Pattern of Sine Waves



▷ Phase Measurement

Measurement with the Lissajous Pattern

Phase differences between two signals can be calculated from Equation 3-10 by displaying a Lissajous pattern with an X-Y scope (refer to Figure 3-21), as described in, "Frequency Measurement."

$$\text{Phase difference angle} = \sin^{-1} \frac{A}{B} \dots\dots\dots (3-10)$$

This method is, however, restricted to frequencies below 2 MHz due to phase distortion in the instrument at higher frequencies.

Phase Measurement by Dual Trace Operation (when the two frequencies are equal)

Fig. 3-19 Lissajous Patterns for Various Frequency Ratios

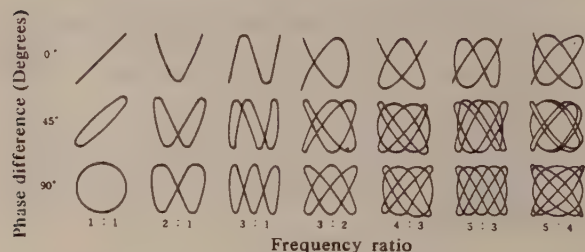


Fig. 3-21 Phase Measurement with Lissajous Pattern

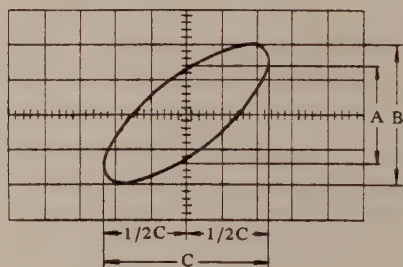


Fig. 3-23 Phase Measurement of Two Signals of Different Frequencies

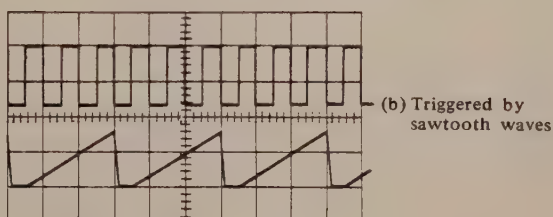
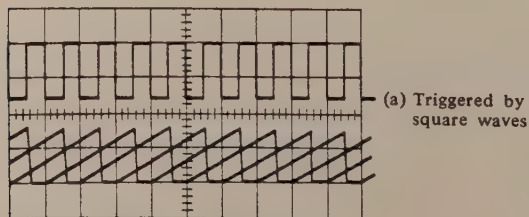


Fig. 3-22 shows an example of a phase difference measurement between two sine waves (leading and lagging wave).

For this method, the TIME/CM switch and the VARIABLE control are set so that one cycle of the signal is displayed in exactly 9 cm. One vertical division (1 cm) represents 40° — since one cycle = $2\pi = 360^\circ$ is displayed in 9 divisions, and the phase difference between the signals is calculated by equation (3-11).

$$\text{Phase differences (degree)} = \text{Horizontal distance between the leading wave and the lagging wave on the graticule (T)} \times 40^\circ \dots\dots\dots (3-11)$$

Dual Trace Measurement of Signals of Different Frequencies

Fig. 3-23 shows an example of a pulse shaper output and a sawtooth wave triggered by this pulse. To measure

Fig. 3-20 Lissajous Patterns for Different Waveforms
(Frequency Ratio 1 : 1)

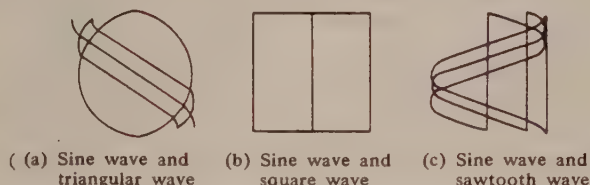
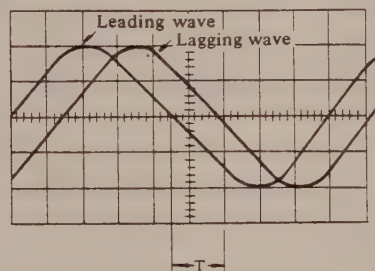


Fig. 3-22 Phase Measurement of Two Signals of the Same Frequency



the phase difference of two signals having different frequencies (provided the frequency ratio is an integer), the sweep must be triggered by the lower frequency signal. If the sweep is triggered by the higher frequency signal (square wave in this example), the sawtooth wave signals will not be triggered properly.

▷ Measurement of Non-Electrical Phenomena

Voltage is the only electrical phenomenon which can be measured directly, on a synchroscope. Synchrosopes, however, are widely used for measuring phenomena other than voltage as a result of the development of transducers which convert these phenomena into voltage. Transducer type measurements are now practiced in various fields such as kinetics, optics, temperature, and chemistry.

A summary of typical transducers will be described in the following paragraphs.

Measurement of Kinetic Variation

The following properties of material under external force are employed to convert kinetic variations such as displacement, distortion, pressure, or vibration, into electrical variations.

- (1) Resistance variations of wire resistors and semiconductors due to externally applied force. These devices are known as strain gages.
- (2) Piezoelectric elements such as quartz crystals or barium titanate which produce an electrical output propor-

tional to an externally applied force.

(3) Capacitance pickup which varies its internal capacitance in accordance with an externally applied force.

(4) Ferromagnetic pickup which varies its magnetic properties with external force.

(5) Electromagnetic pickup which converts displacement into electromagnetic force.

Various other types of transducers are also produced. All these transducers are attached either directly or through an adequate material to the object being measured.

These transducers may be classified according to their purpose, such as distortion measurement, pressure, or vibration, etc. These devices can be further classified into types which operate at high temperature or humidity, high frequency, large amplitude vibration, and those which are extremely sensitive for minute vibrations, etc.

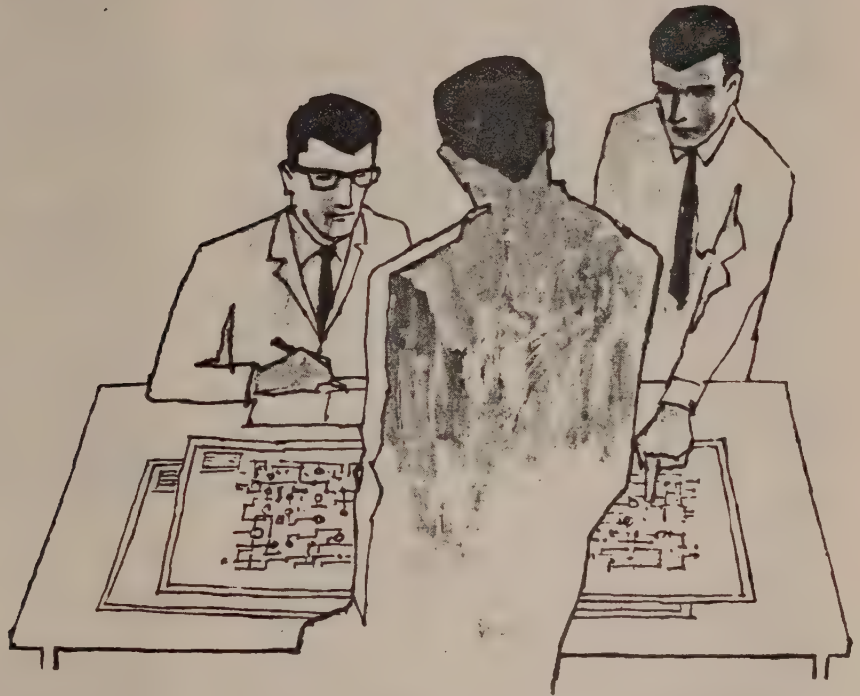
Various new transducers are being developed, and additional applications using synchrosopes for measuring physical properties are expected.

Optical and Temperature Measurement

Transducers which convert light variations into electrical variations are commonly known as photoelectric cells and phototransistors. Photomultiplier tubes are used for detecting very dim or minute changes of light.

Thermistors, of which electrical resistance varies with temperature, and thermocouples composed of two dissimilar metals which generate an electromotive force when their junction point is heated, are the most commonly used thermal transducers.

CHAPTER 4 CIRCUIT DESCRIPTION



The operation of individual circuits will be described in this chapter to aid in the maintenance and calibration of this instrument.

The overall operation will be described first, using the block diagram in Fig. 4-1. A detailed description of individual circuit operation follows.

General	4- 2
Circuit Description	4- 3
Vertical Input and Attenuator	4- 3
CH 1 Preamplifier	4- 3
CH 2 Preamplifier	4- 3
Switching Circuit	4- 5
Vertical Main Amplifier	4- 6
Trigger Amplifier	4- 7
A Trigger Generator	4- 8
A Sweep Generator	4-13
B Trigger Generator	4-18
B Sweep Generator	4-18
B Ends A Control Circuit	4-21
Horiz Amplifier	4-22
Z Amplifier	4-24
CRT Circuit	4-25
Low Voltage Power Supply	4-26
Calibrator	4-28

► General

Circuit configuration of this instrument is shown in Fig. 4-1. Each block operates, as the final purpose, to deflect electron beam of the CRT.

Two independent preamplifiers are provided for the vertical amplifier system. The input signal is fed to the INPUT connector, then converted into a balanced signal and fed to the switching circuit after amplification.

The switching circuit selects the input signal (CH 1, CH 2 or both), which is fed to the main amplifier, by diode gate switching. The MODE switch selects either CH 1, CH 2, the algebraic sum of the two signals (ADDED), or the two signals electronically switched (ALT or CHOP). In the ALT position of the MODE switch, the diode gate is switched by ALT_synchronizing pulse via Z amplifier from the sweep generator, and the CH 1 and CH 2 signals are alternately displayed as complete sweeps. In the CHOP mode the two signals are chopped, regardless of the sweep rate, at a repetition rate of approximately 1 MHz. In this mode, the switching waveform (chop blanking pulse) is supplied to the Z axis amplifier to blank transients of the switching.

The main amplifier functions to amplify the balanced signal up to a sufficient level to deflect vertically the electron beam of the CRT.

The signal fed to the INPUT connector is also internally fed to the trigger amplifier where it is amplified and fed to the A and B trigger generators. The signal fed to the CH 2 INPUT is amplified by 5 times at the trigger amplifier and supplied to the CH 2 OUT connector.

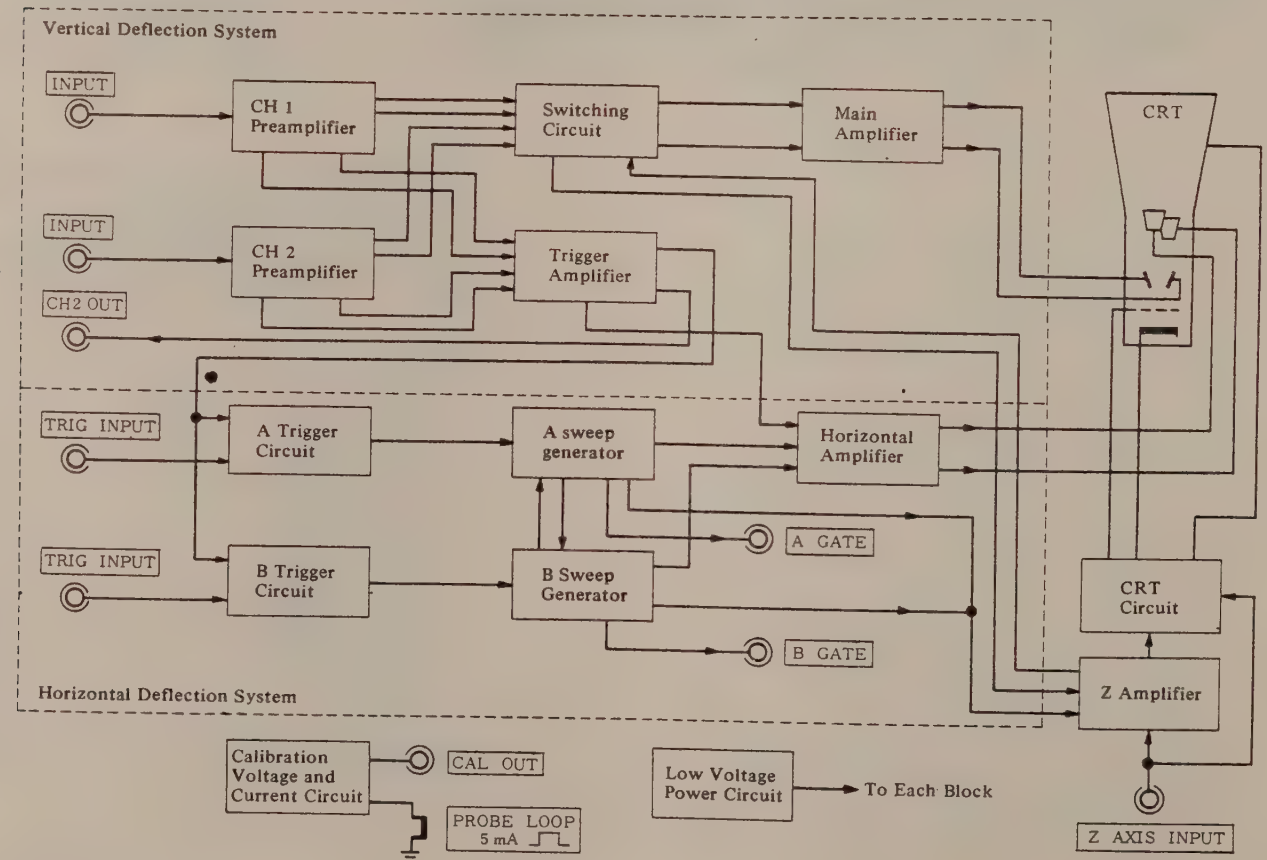
The A and B trigger generators convert the trigger signal into a trigger pulse having a constant amplitude and rise time. The trigger pulse may also be generated by an external trigger signal supplied to the TRIG INPUT or by line frequency signal.

The A sweep generator is triggered by the A trigger generator, and the B sweep generator by the B trigger generator. The A and B sweep generators are interconnected for delayed sweep operation. Three types of interconnection are provided; the A $\rightarrow$ B connection for the delay sweep, the A $\leftrightarrow$ B connection to terminate the B sweep which follows the A sweep (A ENDS B) and to terminate the A sweep which follows the B sweep (B ENDS A).

Unblanking signals fed from the A and B sweep generators to the Z axis amplifier are superimposed each other provided that the mode switch is set to the A INTEN BY B position, and the intensity of superimposed portion is especially increased. Each gate signal is obtained at the A GATE and B GATE connectors.

If this instrument is used as an X-Y scope, the Y axis

Fig. 4-1 Basic Block Diagram



input signal is applied to the CH 1 INPUT terminal and fed to the vertical deflection plates. The X-axis input signal is applied to the CH 2 INPUT and fed to the horizontal deflection plates through the CH 2 preamplifier, trigger amplifier, and the horizontal amplifier. A Lissajous pattern can then be obtained by appropriate X and Y signals.

The X axis amplifier amplifies the unblanking signals from the A and B sweep generators, the chop blanking pulse from the switching circuit, and the external intensity modulation signal fed from the Z AXIS INPUT connector. These signals and voltages are fed through the CRT circuit to the control grid of the CRT to control the trace intensity.

A part of the unblanking pulse from the A and B sweep generators is amplified and differentiated, then fed to the switching circuit as an alternate synchronizing pulse.

The CRT circuit produces the high voltage required to emit and accelerate the electron beams.

The 6.3 V AC used for the CRT filaments and graticule illumination lamps, and low dc voltages required for the operation of circuits are obtained from the low voltage power supply.

The calibration voltage and current supply produces the calibration voltage used for the calibration of internal circuits and the voltage probe, as well as the calibration current for the current probe.

► Circuit Description

Since the overall and basic operation of each block is described in the previous paragraph, referring to the Basic Block Diagram, the operation of each circuit will be explained in the following paragraphs: (Refer to the corresponding block diagram and circuit diagram on back of this manual.)

For circuits which consist of similar configurations (i.e. CH 1 and CH 2 preamplifiers), the former will be fully explained but for the latter only the different points from the former will be described.

► Vertical Input and Attenuator

The input signal applied to the INPUT connector is fed to the input attenuator through the AC-GND-DC switch. In the AC position, capacitor C 1 blocks the dc component of the input signal and allows only the ac component to pass, while in the DC position, the input signal is fed directly to the input attenuator. The GND position of the switch opens the signal path and grounds the input attenuator. This position is provided to confirm the zero level of the input signal which is applied to the INPUT connector. Resistor R34 and capacitor C34 which have constant values are used to eliminate ringing of the rectangular input signal.

The attenuator attenuates only the input signal and provides ten vertical deflection sensitivity ranges. The positions 5 and 10 mV/cm are used to change the emitter resistance of preamplifier transistors TR9 and TR10 (described later), and in the positions above 20 mV/cm the input signal is attenuated by parallel-capacitance frequency compensated resistive attenuators.

The input resistance, as viewed from the INPUT side, is retained at one megohm at all attenuator positions.

► CH 1 Preamplifier

The block diagram of the CH 1 preamplifier is shown in Fig. 4-2. This preamplifier amplifies the input signal from the attenuator and feeds the signal to the switching circuit.

A junction-type FET (field effect transistor), TRIA, forms the input source follower circuit, which is equivalent to a vacuum tube cathode follower, in order to provide a high input impedance and reduce the influence on the circuit to be measured. The output impedance is reduced to drive the succeeding amplifier stage.

D1A is provided to protect TRIA from damage due to an excessively large negative input signal. For a large positive input signal, the gate and source of TRIA has diode effect which attenuates the input signal through voltage dropping resistor R35A by passing current from gate to source.

For the large negative input signal, transistor TRIA is reverse-biased to make D1A conduct, thereby attenuating the input signal.

The first stage transistors TR3A – TR6A establish a balanced cascade amplifier which performs the phase inversion. The phase of the input signal is inverted by TR3A and the amplified output signal appears at the collectors of transistors TR5A and TR6A as a balanced signal.

The bridge circuit composed of diodes D5A, D6A, and resistors R66A, R67A is inserted between the collectors of transistors TR3A and TR4A.

The dc current which flows through D5A and D6A is subject to change due to the resistance value variations of VARIABLE R71A. That is, the changes in the dc current which flows in the non-linear characteristic curve of diodes D5A and D6A vary their internal impedances, and thereby change the current amplitude distributed to the bridge circuit from among the output current of TR3A and TR4A. For this reason, since the amplitude of the signal current which flows into TR5A and TR6A is varied and the output gain of the first stage can be changed continuously by the VARIABLE (R71A) switch.

The next stage amplifier consists of two stages of emitter coupled amplifiers and amplifies the balance signal from the first stage again.

The emitter resistance of transistors TR9A and TR10A is changed by the attenuator switch when the deflection sensitivity is changed from 5 to 10 mV/cm. Part of the output signal from the collectors of grounded base amplifiers TR11Aa, b is fed to the trigger amplifier as a trigger signal for CH 1.

The final stage of the preamplifier forms an amplifier together with a dealy cable drive circuit with the diode gate circuit inserted between them. The details of this amplifier will be described later in the paragraph, SWITCHING CIRCUIT. The POSITION control, R137A, alters the base dc potential of TR14A and TR15A, and determines the vertical position of the trace.

► CH 2 Preamplifier

The CH 2 preamplifier employs the same circuit configuration as the CH 1 preamplifier as shown in Fig. 4-2 except that the diode gate circuit is added.

The diode gate circuit switches the polarity of the CH 2 waveform when measuring the sum or difference of the input signals applied to the CH 1 and CH 2 INPUT connec-

tors. When the CH 2 POLARITY switch is turned to the NORMAL position, the outputs of TR12B and TR13B are sent to the bases of TR14B and TR15B, respectively, as the diodes D13B, D14B, D15B and D16B are cut off, and D9B, D10B, D11B and D12B are turned on. When the

CH 2 POLARITY switch is turned to the INV position, the outputs of TR12 and TR13 are sent to the bases of TR15 and TR14, respectively, as the diodes D9B, D10B, D11B and D12B are cut off, and D13B, D14B, D15B and D16B are turned on.

Fig. 4-2 Block Diagrams of CH 1 and CH 2 Preamplifiers

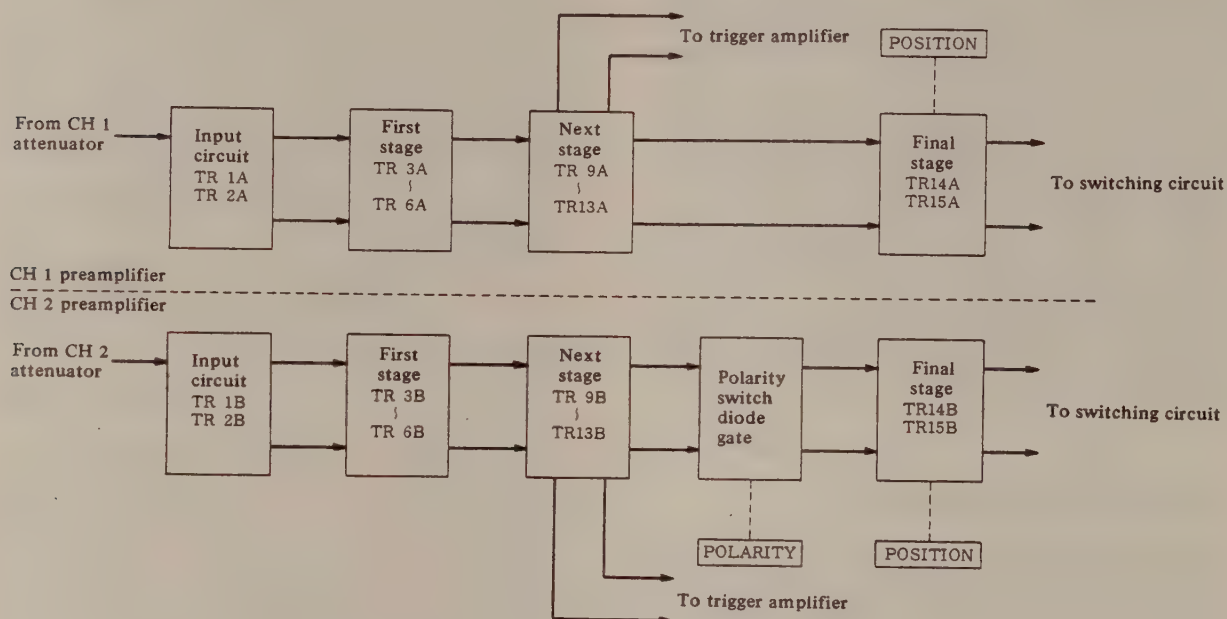
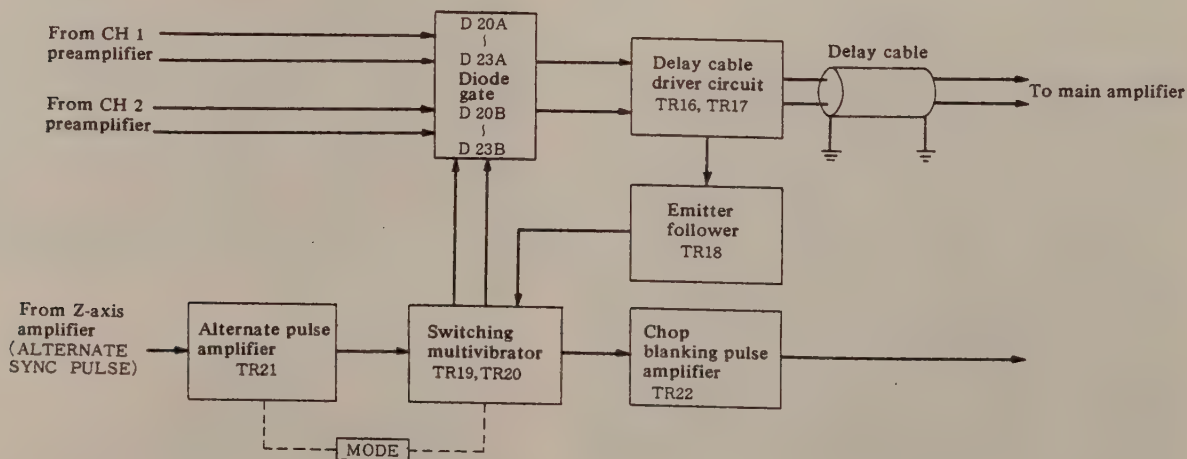


Fig. 4-3 Block Diagram of the Switching Circuit



▷ Switching Circuit

The configuration of the switching circuit is shown in Fig. 4-3. The diode gate switches the connection of the balanced output from the CH 1 and CH 2 preamplifiers to the main amplifier based upon the range selection of the MODE switch.

CH 1: When the MODE switch is in the CH 1 position, the anodes of diodes D20B and D21B reach +12 V through resistor R180 and the anode potential of diodes D20A and D21A is equal to that at the connection of resistors R175 and R176 (refer to Fig. 4-4). Therefore, D20B and D21B are forward biased and are turned on due to a rise in the cathode voltage which cuts D22B and D23B off.

On the other hand, D20A and D21A are reverse biased and are cut off turning D22A and D23A on. Therefore, only the balanced output signal from the CH 1 preamplifier is sent to the delay cable driver circuit.

CH 2: In this case, only the balanced output signal from the CH 2 preamplifier is sent to the delay cable driver circuit, because when the MODE switch is in the CH 2 position, the anodes of D20A and D21A attain a potential of +12 V through resistor R179 and the anode potential of D20B and D21B is equal to that at the connection of R173 and R174.

ALT: In the ALT mode, the +12 VDC power is supplied to the emitter of TR21 (alternate pulse amplifier) and the switching multivibrator operates as a bistable multivibrator. When transistor TR21 is on, the current is sent to the

switching multivibrator via diodes D33 and D35. Assuming that TR19 is on, current flows through D35 and TR19. Then the collector potential of TR19 increases, diodes D20B, D21B are turned on and D22B, D23B, off.

Otherwise, D20A and D21A are off, and D22A and D23A are on since TR20 is off and its collector potential is rather low. Accordingly, only the balanced output signal from the CH 1 preamplifier is connected to the delay cable driver circuit.

Upon sweep completion, the positive ALT SYNC pulses are applied to the base of TR21 from the Z-axis amplifier through capacitor C102.

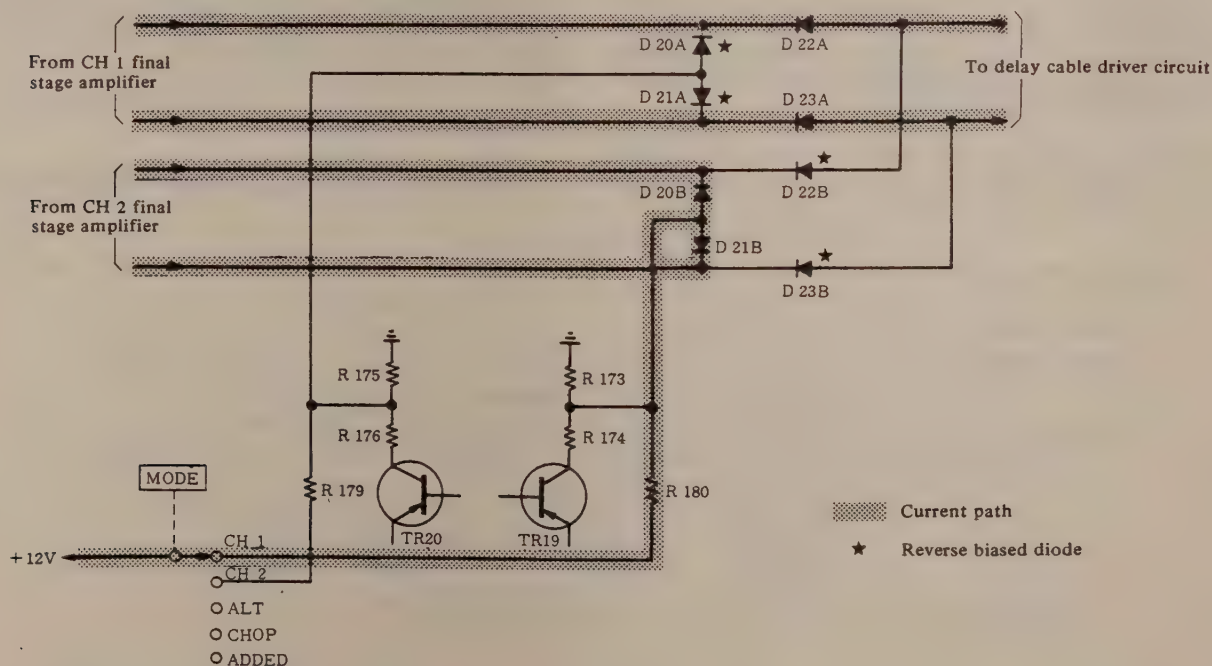
These pulses interrupt the current going to TR21 and turns it instantaneously off. The TR20 side of capacitor C101 is charged positive and the TR19 side is negative when TR21 is on.

The charging continues when TR21 is off and determines which transistor should, in turn, be turned on. When the current again starts to flow through transistor TR21, the emitter voltage of TR20 becomes higher than that of TR19 since C101 is still charged. Then TR20 is turned on. The diode gate operation is reversed to the operation when TR19 is on and only the balanced output signal from the CH 2 is fed to the delay cable driver circuit.

The input signal connected to the CH 1 and CH 2 INPUT appears alternately on the CRT screen.

TR18 is an emitter follower which provides feedback from the delay cable driver circuit to operate the diode gate with a minimum switching signal level. The emitter of TR18 is connected to the cathode side of D31 and D32 via D30, and the voltage at which the diode gate is opened or closed is thus held at a minimum.

Fig. 4-4 Diode Gate Operation (CH 1 position)



CHOP: When the MODE switch is set to the CHOP position, the emitters of TR19 and TR20 are connected to the +12 V power supply through resistor R186 or R187 and the primary coil of T180 to permit the switching multivibrator to operate as a free-running astable multivibrator at a frequency of approximately 1 MHz. If TR19 conducts, only the balanced output signal from the CH 1 preamplifier will be fed to the delay cable driver circuit turning D20B, D21B, D22A and D23A on, and D22B, D23B, D20A and D21A off.

The frequency of the free running multivibrator is determined by the constants C101, R186, and R187. Operation of the multivibrator is as follows: When TR19 conducts, C101 starts to charge towards +12 V through R186, the emitter of TR20 slowly approaches +12 V together with C101. The base potential of TR20 is determined by the voltage divider consisting of R182 and R184, which is between the collector of TR19 and +12 V. When the emitter potential of TR20 becomes slightly higher than its base potential, TR20 is reversed on and its collector potential is stepped up to a positive level. The base potential of TR19 at this time, is also stepped up to a positive level through divider R181 and R185, causing the TR19 to be turned off. Capacitor C101 again starts to charge toward +12 V through the other resistor R187, then the emitter of TR19 slowly approaches +12 V together with C101 until TR19 is turned on and TR20, off. The switching operations of these transistors are repeated in this manner.

Diodes D33, D34, and D35 are reverse biased by the +12 V applied through T180 for effective free running (only CHOP position). The emitter follower TR18, as in the ALT mode, controls the diode gate switching voltage to be held at a minimum switching level.

The chop blanking pulse amplifier TR22 feeds pulses to the Z-axis amplifier to blank the transients display which occurs when CH 1 and CH 2 are switched. The pulse signal when the switching multivibrator reversed is fed to the base of TR22 through transformer T180, where this signal is amplified and clipped; thereby, only the positive pulses synchronized with the switching transient of CH 1 and CH 2 are fed to the Z-axis amplifier.

ADDED: When the MODE switch is set to the ADDED position, both TR19 and TR20 are cut off, and D20A, D21A, D20B, and D21B are also turned off. At the same

time, D22A, D23A, D22B, and D23B conduct. Therefore, both balanced output signals from CH 1 and CH 2 are fed to the delay cable driver circuit. In this mode, the diode gate requires twice the current of other modes, so this current is applied through resistors R153 and R154 by changing position of the MODE switch.

The balanced signal from CH 1 and CH 2 are fed to the delay cable driver circuit through switching of the diode gate. The delay cable driver circuit amplifies the signal in conjunction with the final stages of the CH 1 or CH 2 preamplifier. This amplifier forms a low impedance negative feedback circuit composed of resistors R156 and R157, which prevents a deterioration of frequency response caused by the complex circuit configuration and drives a delay cable.

▷ Vertical Main Amplifier

The circuit configuration of the main amplifier is shown in Fig. 4-5. This circuit amplifies the balanced signal from the delay cable amplifier up to level sufficient to deflect the electron beam.

Delay Cable

Used to delay the balanced signal from the delay cable driver amplifier approximately 80 nsec to display the rising edge of input pulses by using an internal trigger signal.

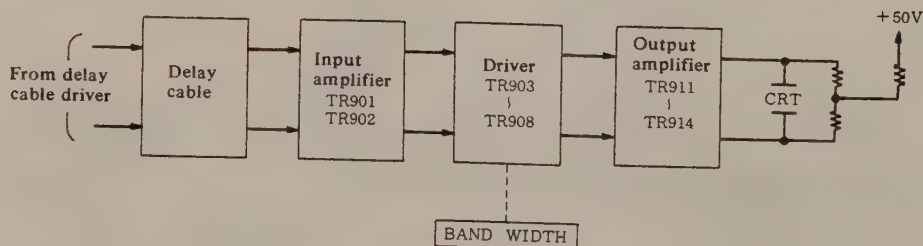
Input Amplifier

The input amplifier composed of TR901 and TR902 forms an emitter coupled type balanced amplifier which has a relatively high input impedance and provides impedance matching with the delay cable at its base through resistors R901 and R902. This amplifier amplifies the balanced signal from the delay cable.

Intermediate Amplifier (Driver)

The balanced signal from the input amplifier is applied to the emitters of transistors TR903, TR904, TR905, and

Fig. 4-5 Block diagram of vertical main amplifier



TR906 which form a grounded base amplifier and is amplified.

When the BAND WIDTH control is set to the FULL position, TR905 and TR906 do not amplify the signal because they are reverse biased, but TR903 and TR904 amplify the signal since they are forward biased. Conversely, when the BAND WIDTH control is in the 50 MHz position, TR903 and TR904 are reverse biased not to amplify and TR905 and TR906 are forward biased to amplify the signal. Capacitors C906 and C907 which are connected to the output side of TR906 and TR905 attenuate the frequency signal higher than 50 MHz. The output signals from TR903 and TR904 (FULL BAND position) are further amplified by transistors TR907 and TR908.

Output Amplifier

This amplifier is composed of the emitter-follower comprising TR911 and TR912, emitter coupled balanced amplifier, TR913 and TR914, and TR909 and TR910 which operate a neon lamp as a beam indicator. The emitter-follower provides low impedance to drive a balanced amplifier, which amplifies the balanced signal up to a level sufficient to deflect the electron beam. Resistors R980 to R983, R985 and R986 are the load resistance of the balanced amplifier. A variable resistor R984 is used to adjust the correct termination of the vertical deflection systems of the CRT.

▷ Trigger Amplifier

The trigger amplifier is composed of several circuits as shown in Fig. 4-6. This amplifier amplifies the balanced trigger signal output from the CH 1 or CH 2 preamplifier, and feeds it to the trigger generator. This amplifier also boosts the CH 2 input signal five times, supplies it to the CH 2 OUT connector, and feeds the X signal to the horizontal amplifier during XY scope operation.

CH 1 Amplifier

The trigger signal from the TR11Aa and TR11Ab of the CH 1 preamplifier is fed to the bases of TR201A and TR202A, and in turn, amplified by TR203A to TR206A as a balanced signal.

CH 2 Amplifier

This amplifier amplifies the trigger signal from the CH 2 preamplifier. Subsequent operation is identical to CH 1.

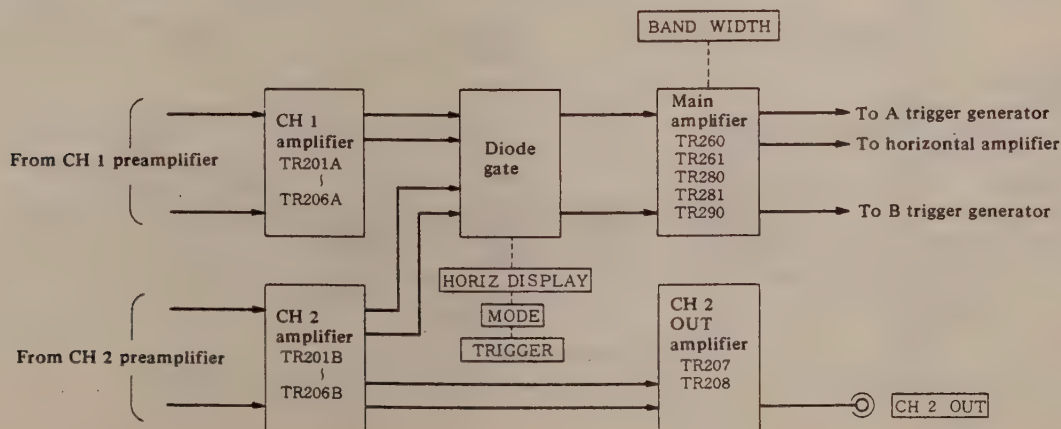
Diode Gate

Depending on the mode selected with the MODE and TRIGGER switches, the diode gate connects the CH 1 or CH 2 trigger signal to the trigger main amplifier. In other words, when the MODE switch is in the CH 1 position, the anodes of diodes D260B and D261B are grounded to allow these diodes to conduct, and diodes D262B and D263B to cut off. At the same time, D260A and D261A cut off, and D262A and D263A conduct. Therefore, only the CH 1 trigger output is fed to the main amplifier (except when the HORIZ DISPLAY switch is set in the CH 1 VERT CH 2 HORIZ position). When the MODE switch is set in the CH 2 position, the afore-mentioned diode gate operation is reversed, and the CH 2 trigger signal is fed to the main amplifier. In ALT, CHOP, or ADDED position of the MODE switch, the diode gate is switched by the TRIGGER switch and selects the CH 1 or CH 2 trigger signal.

Main Amplifier

This amplifier amplifies the CH 1 or CH 2 trigger signal selected by the diode gate operation through transistors TR260, TR261, TR280, and TR281. The collectors of TR280 and TR290 feed a trigger signal to the A trigger generator and B trigger generator, respectively. In the XY

Fig. 4-6 Block diagram of trigger amplifier



scope operation, CH 1 VERT CH 2 HORIZ position, the input signal connected to the CH 2 INPUT connector is fed to the horizontal amplifier from the collector of TR280. When the BAND WIDTH switch is in the 50 MHz position, the neon lamp NE270 is lit.

CH 2 Out Amplifier

A part of the input signal of CH 2 is fed from the trigger amplifier (CH 2 amplifier) to the CH 2 OUT amplifier from which it is supplied to the CH 2 OUT connector.

▷ A Trigger Generator

The circuit configuration of the A trigger generator is shown in Fig. 4-7. The generator produces a pulse output to trigger the A sweep generator. This trigger pulse is shaped with the signal branched from the vertical deflection circuit (internal trigger), the external trigger signal supplied to the TRIG INPUT, or the line trigger signal supplied from the power transformer.

Trigger Signal Selection

The SOURCE switch selects the source of the trigger signal from among the internal signal, external signal, or the line frequency signal. The EXT $\div$ 10 position is used to attenuate the external trigger signal by 1/10. The internal trigger signal is obtained from the vertical input signal through the previously mentioned trigger amplifier. As described under TRIGGER AMPLIFIER, the internal trigger signal is selected, by the MODE and TRIGGER switch, from the CH 1 or CH 2 signal.

For the line trigger, the 6.3 V rms from terminals Nos. 24 and 25 of power transformer T1301 is reduced to

approximately 1.5 V rms by a voltage divider consisting of R1401 to R1411 and then fed through pin P301 No. 19. If the COUPLING switch is set to the LF REJ position, the line signal is attenuated, and line triggering is disabled.

The external trigger signal supplied to the TRIG INPUT connector is fed to the trigger generator when the SOURCE switch is set in the EXT or EXT $\div$ 10 position. The attenuator in the EXT $\div$ 10 position reduces the external trigger signal by 1/10. This switch is used when the external trigger signal is excessively large.

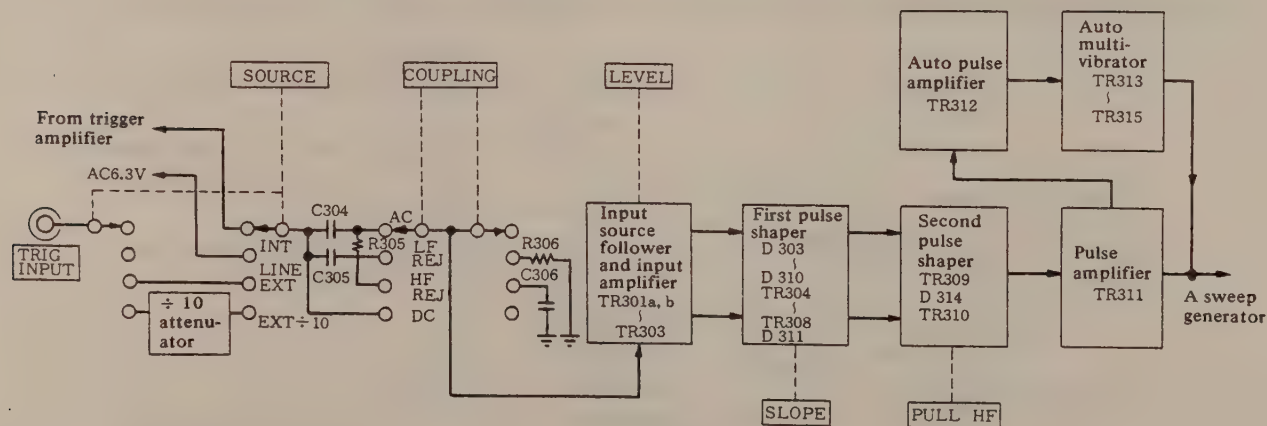
Trigger Signal Input Coupling Selection

The COUPLING switch selects the coupling mode between the trigger signal and the input source follower. In the AC position, capacitor C304 is inserted in series with the input circuit to block the dc component of the input signal while allowing ac signals higher than approximately 30 Hz to pass. In the LF REJ position, a high-pass filter composed of C305 and R306 decouples low-frequency noise superimposed on the trigger signal, and low-frequency components (lower than approximately 30 kHz) of the trigger signal. The low-pass filter in the HF REJ position is composed of C305 and R305. This filter cuts higher frequency components greater than approximately 10 kHz and the high-frequency noise and allows only low-frequency trigger signals (from approximately 30 Hz to 10 kHz) to pass. In the DC position, all input signals are directly coupled to the trigger generator input.

Input Source Follower and Input Amplifier

The input source follower in which FET's (field effect transistors) are employed provides high input and low output impedance. The output signal from the input source follower is fed to the base of TR302 and triggers the

Fig. 4-7 Block diagram of trigger generator



succeeding trigger amplifier. TR301b is used to dc balance of the trigger amplifier and provides the impedance matching. The LEVEL control is a variable resistor to determine the initial triggering point of the trace by changing the dc level. TR302 and TR303 which form a phase inversion amplifier, convert the trigger signal from TR302 into a balanced signal and further amplify it to drive the succeeding pulse shaper.

First Pulse Shaper

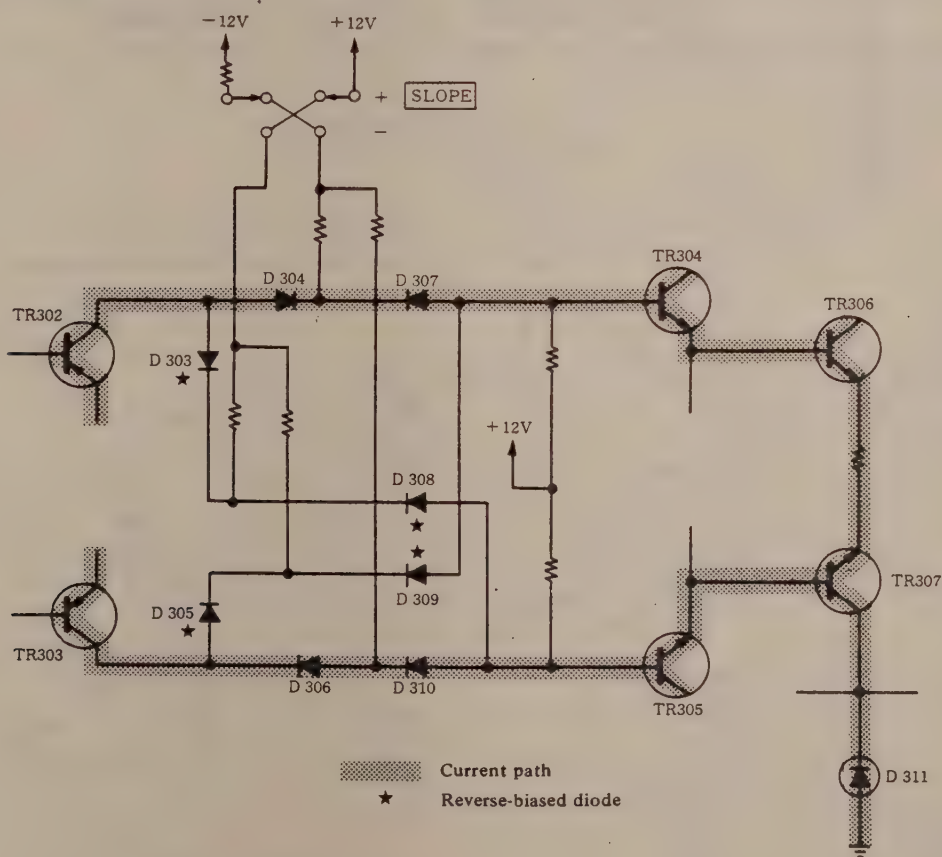
The first pulse shaper is composed of diodes D303 to D310 which form a diode gate and tunnel diode D311 which converts the trigger signal into a rectangular signal. The diode gate is operated by the SLOPE switch and feeds a signal, the phase of which differs 180 degrees according to the positive (+) or negative (-) position of the SLOPE switch, to the collector of TR317.

D311 is operated by the output signal from the diode gate as a bistable multivibrator. With the SLOPE switch set to the + position, +12 V is connected to the cathodes of

D303, D305, D308, and D309 (as shown in Fig. 4-8), then they turn off, and -12 V is connected to the cathodes of D304, D306, D307, and D310, then they conduct. Current flows as shown in Fig. 4-8. In other words, the input signal fed to the base of TR302 becomes a balanced signal which is applied to TR302 to D304 and TR303 to TR305, and further applied to D311 from the collector of TR307.

R348 to L306 are inserted in parallel with D311 and the load line of diode D311 has a gradient as shown in Fig. 4-9. When the trigger signal (sine wave) is fed, as shown in Fig. 4-9, from the gate of TR301a and the trigger level is set by the LEVEL control, through the current flows the D311, I, to flow at the time 0 and the operating point of D311 on the characteristic curve is at point A. When the trigger signal level increases and the current i_2 which exceeds the trigger level starts to flow (t_1), D311 is stepped up to point C in the instantaneous period. The trigger signal is further boosted and the operating point shifts to point D. When the trigger signal drops and become more negative than the trigger level (t_2), the operating point steps to point F and then return to point A. In this way, tunnel diode D311 is triggered by the trigger signal (sine wave). By above

Fig. 4-8 Current path in the first pulse shaper (Slope switch is in the + position.)



operation, it generates the rectangular waveform shown in Fig. 4-9 at the cathode of D311. This signal is differentiated by C318, R352, and R351, then fed to the base of TR308 to be sent to the next stage as a trigger pulse from the emitter. Since this trigger pulse is generated at time $t_1, t_3, t_5, \dots$, these pulses can be generated wherever the positive-going slope position of the trigger signal you may need by changing a trigger level determined by the LEVEL control. The trigger pulses synchronizes and triggers also by the second pulse shaper. This means that since the sawtooth sweep signal is generated and synchronized with the trigger pulse from the first pulse shaper, and the amplified input signal fed to the vertical deflection plate of the CRT and the trigger signal fed to the D311 are in phase, the sweep can be triggered from an optional point on the positive-going slope of the input signal waveform. When the SLOPE switch is set to the $-$ position, the path in which current flows through the diode gate is as shown in Fig. 4-10, and the phase of the trigger signal applied to TR304 and TR305 is reversed of that in which the SLOPE switch is in the $+$ position. In other words, the signal is applied from TR302 to TR305 or from TR303 to TR304, and the trigger signal shown in Fig. 4-11 is fed from the collector of TR307 to D311 since the phase is the reversed of that when the SLOPE switch in the $+$ position. Assuming that the trigger level is set by the LEVEL control as shown in Fig. 4-11, D311 allows the current i_1 to flow at

the time, and the operating point of D311 is at point A on the characteristic curve. Working on the same principle as the $+$ position of the SLOPE switch, D311 is triggered by the trigger input signal. However, the trigger pulse is generated at the time $t_2, t_4, \dots$ in which the phase the phase is shifted 180 degrees. Now that the phase of the trigger signal fed to the tunnel diode D311 is already shifted 180 degrees against the positive-going slope signal, the sweep can be triggered from an optional point on the negative-going slope of the input signal waveform. Variable resistor R341 inserted between TR306 and TR307 provides trigger sensitivity.

Second Pulse Shaper

The second pulse shaper which forms a multivibrator composed of the limiter D312, D313 and tunnel diode D314, is operated by the trigger pulse fed from the first pulse shaper.

The negative pulse applied to TR309 is converted into a positive pulse by the collector and fed to the cathode of D313 through D312.

The operation of tunnel diode D314 differs depending on the push or pull position of the A SWEEP STABILITY control. This operation shifts the load line of D314 and switches it to monostable or astable. When this STABILITY

Fig. 4-9 Operation of tunnel diode (SLOPE switch in the $+$ position)

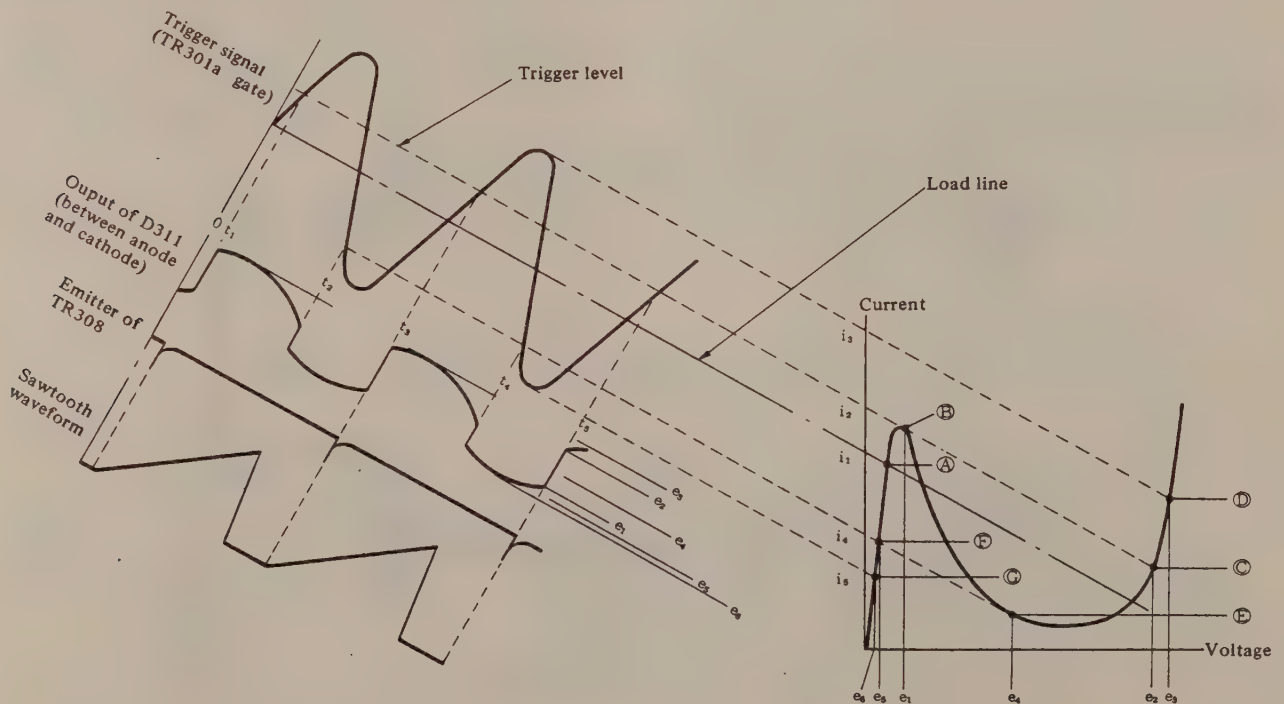


Fig. 4-10 Current path of the first pulse shaper (SLOPE switch in the — position)

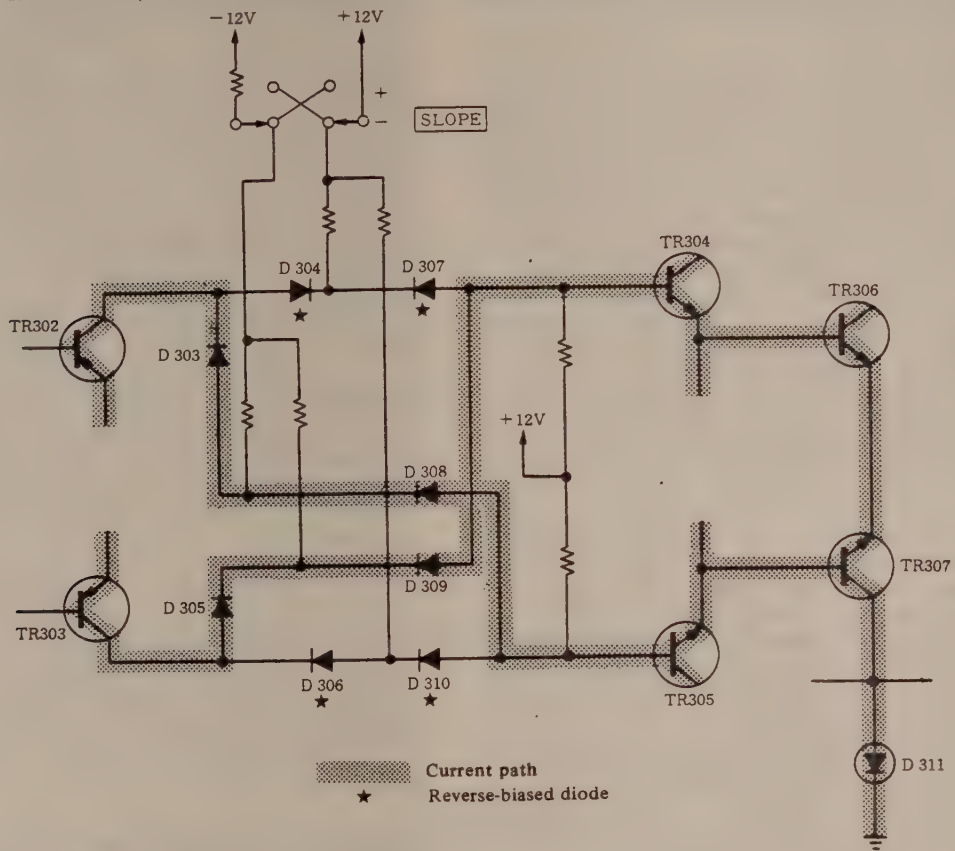
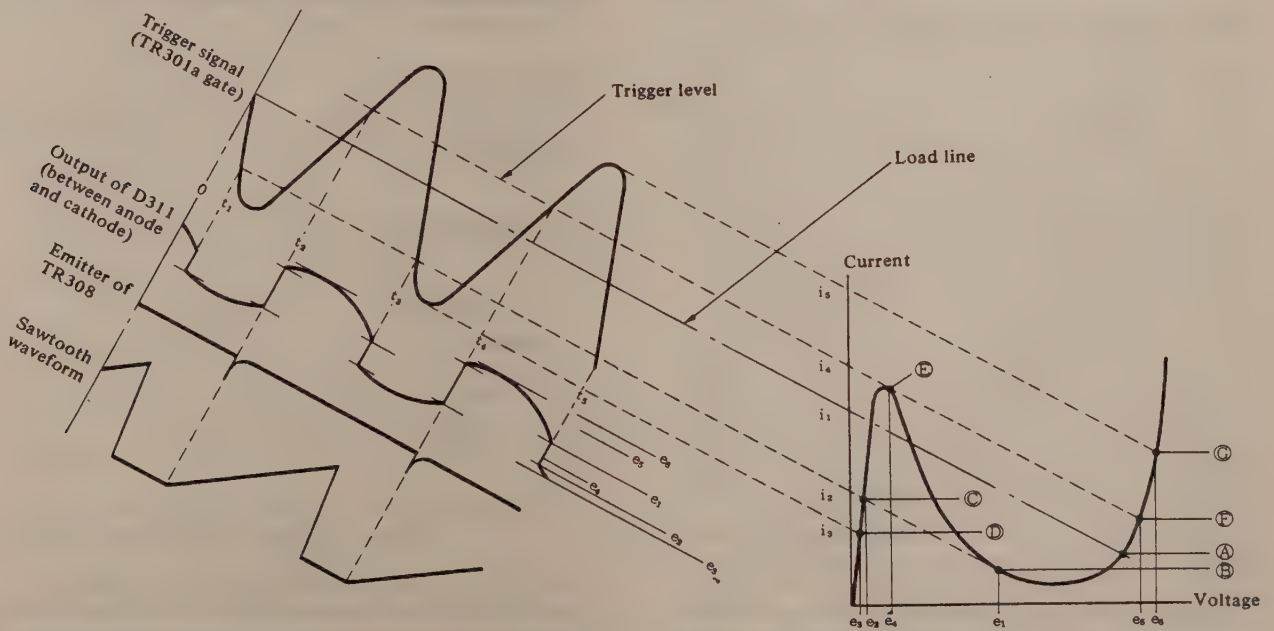


Fig. 4-11 Operation of tunnel diode (SLOPE switch in the — position)

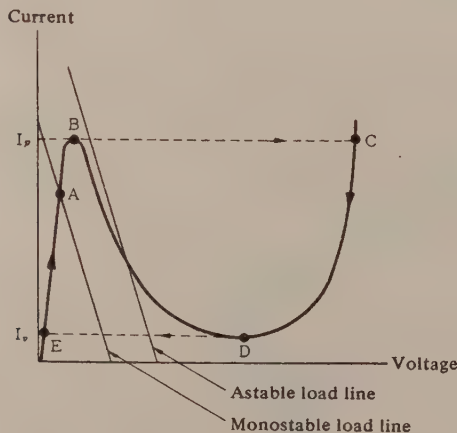


control is depressed, the second pulse shaper becomes monostable; when pulled, the shaper is astable and oscillates a signal of approximately 30 MHz.

When the stability control is depressed Tunnel diode D314 operates as a monostable multivibrator. When the trigger pulse is not applied, the operating point of D314 is at point A as shown in Fig. 4-12. Assuming that a positive trigger pulse is supplied to D313 through D312 making it cut off, the current which flows through D314 increases and the operating point of D314 shifts as follows. The operating point which passed through point B moves to point C which is a high voltage area and reaches point D, and returns to point A through E which is a low-voltage area. The operating point of D314 remains at point A until the next trigger pulse is applied to the base. In other words, the operating point of D314 shifts sequentially to the low-voltage area, high voltage area and again to the low-voltage area for each trigger pulse, and D314 feeds the positive pulses synchronized with the trigger pulse to the base of TR310.

When the stability control is pulled The tunnel diode D314 operates as an astable multivibrator and self-oscillates a signal of approximately 30 MHz. When a trigger pulse with frequencies greater than 30 MHz is fed to the cathode of D313 through D312, D314 oscillates the signal synchronized with the 30 MHz trigger pulse and feeds the positive pulse shaped through the B-C-D-E-B loop of the operating point shown in Fig. 4-12 to the base of TR310. Therefore, the higher frequency trigger pulse is down to the 30 MHz trigger pulse. The trigger pulse shaped by the second pulse shaper is fed to the succeeding auto pulse amplifier and auto multivibrator from the emitter of TR310.

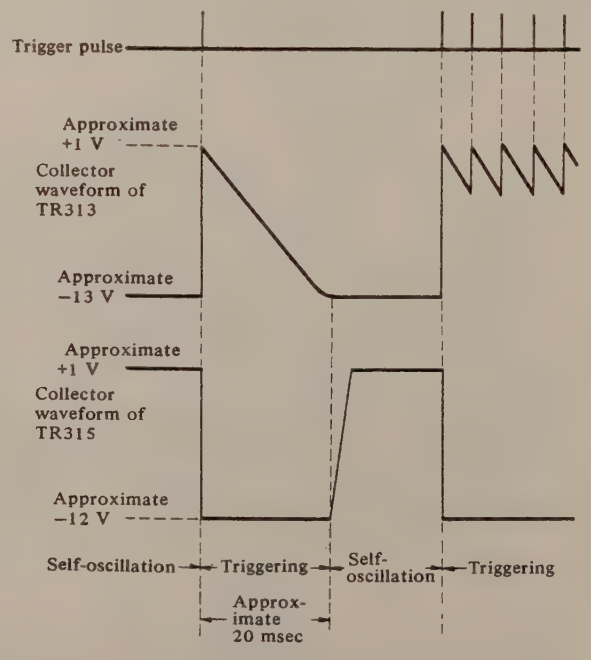
Fig. 4-12 Characteristic curve of tunnel diode (D314, D614)



Auto pulse amplifier and auto multivibrator

By setting the A SWEEP MODE switch to the AUTO position, operation of the A sweep generator is switched to triggering, or self-oscillation. In other words, this sweep generator is triggered when trigger signals are present, and self-oscillates during the absence of these signals. When the trigger pulse is not present: In this case, the auto pulse amplifier TR312 is separated and the auto multivibrator operates as follows: The current flows toward D320 through T301 and R380, so that the base potential of TR313 is clamped at approximately +0.7 V and the base of TR314 is held at about +0.35 V by the voltage divider consisting of R381 and R384. Then, TR314 conducts and TR313 cuts off. Capacitor C338 is charged toward negative through R385, diodes D322 and 323 conduct, and current flows through R383, TR314, and R387 toward the -12 V power source. At the same time, TR315 is cut off since reverse bias is applied between the emitter and base. D324 is also turned off. Thus, D325 allows some current to flow through R389 to shift the operating point of gate multivibrator D401 employed in the A sweep generator from point A to B as shown in Fig. 4-15. The fact that the operating point of D401 is at point B indicates that the A sweep generator is in self-oscillation as described under A SWEEP GENERATOR. When the trigger pulse is present: The negative pulse is fed to the base of TR313 from TR312 and T301 simultaneously with the trigger pulse applied to the A sweep generator as a positive pulse from TR311 and T302 making TR313 on, and TR314 off. Therefore, the collector potential of TR313 is stepped to positive and C338 is rapidly discharged (refer to Fig. 4-13). Then D322 and 323 are cut off, TR315 conducts and -12 V

Fig. 4-13 Operating waveforms of auto multivibrator



appears on the collector. D324 also conducts and D325 is turned off. Conversely, the operating point of D401 moves to the point A shown in Fig. 4-15 and the A sweep generator is triggered.

When the trigger pulse is removed, TR313 again turns off and TR314 conducts. The collector potential of TR313 drops at a time constant determined by R385 and C338 until it reaches approximately -13 V, where D322 and D323 conduct and TR315 cuts off. The collector potential rises to a positive one volt. If the next trigger pulse appears sequentially before the collector potential of TR315 drops as shown in Fig. 4-13 (until D322 and D323 conduct), TR315 is held on and the triggered operation of the sweep generator is retained. However, when the interval between succeeding trigger pulses is longer than approximately 20 msec (50 Hz), TR315 is turned off, and the A sweep generator operates in the self-oscillation mode.

When the A SWEEP MODE switch is set to a position except AUTO, $+12$ V is connected to the base of TR314 through R382, and TR314 is turned off causing the collector potential to drop. As TR315 conducts and the current flows through D324, the anode voltage of D325 is decreased and D325 is turned off.

▷ A Sweep Generator

The circuit configuration of the A sweep generator is shown in Fig. 4-14. When the HORIZ DISPLAY switch is set to a position except CH 1 VERT CH 2 HORIZ, three operation modes NORMAL trigger, AUTO trigger, and SINGLE SWEEP are available by switching the A SWEEP MODE.

The A sweep generator provides the following four types of signals.

- (1) Sawtooth wave — The sawtooth wave is fed through the horizontal amplifier to the horizontal deflection plates of the CRT. The signal is also fed to the B sweep generator in order to produce the delay pulse.
- (2) Unblanking signal to intensify trace and blank retrace — This signal is fed to the Z axis amplifier and then given to the first control grid of the CRT.
- (3) Positive gate pulse provided during the positive-going slope of the sweep waveform — Fed to the A GATE output connector located on the right side panel.
- (4) A ENDS B pulse generated to eliminate the unnecessary B sweep during A INTEN BY B, or DLY'D (B) sweep — Fed to the B sweep generator.

When the earlier mentioned three operations, NORMAL, AUTO, SINGLE trigger, are performed, the following three signals are applied to the A sweep generator.

- (1) Trigger pulse to generate the sawtooth wave — Fed from the A trigger generator.
- (2) Reset pulse to perform single sweep — Supplied from the B ENDS A control circuit.
- (3) B ENDS A pulse to interrupt the A sweep after the B sweep, when the HORIZ DISPLAY switch is set to the A INTEN BY B or DLY'D (B) position — Given from the B ENDS A control circuit.

Normal trigger operation (Basic operation)

Normal trigger operation of the A sweep is performed by setting the HORIZONTAL DISPLAY switch to any

position other than CH 1 VERT CH 2 HORIZ and the A SWEEP MODE switch to the NORM position. Strictly speaking, these normal triggered operations differ to some extent from the position of the HORIZ DISPLAY switch. For simplicity, an operation in which the HORIZ DISPLAY switch is set to the A position will be used as an example.

Assume a condition before the sweep starts wherein no trigger signal is present. TR418 in the sweep reset circuit is cut off and D325 in the A trigger generator is also cut off, the current flows relatively small through gate multivibrator D401 (tunnel diode) and the operating point of the diode is placed in the low-voltage region, C (refer to Fig. 4-15). Therefore, the gate amplifier TR401 is cut off and the collector potential is clamped by the emitter potential of TR403.

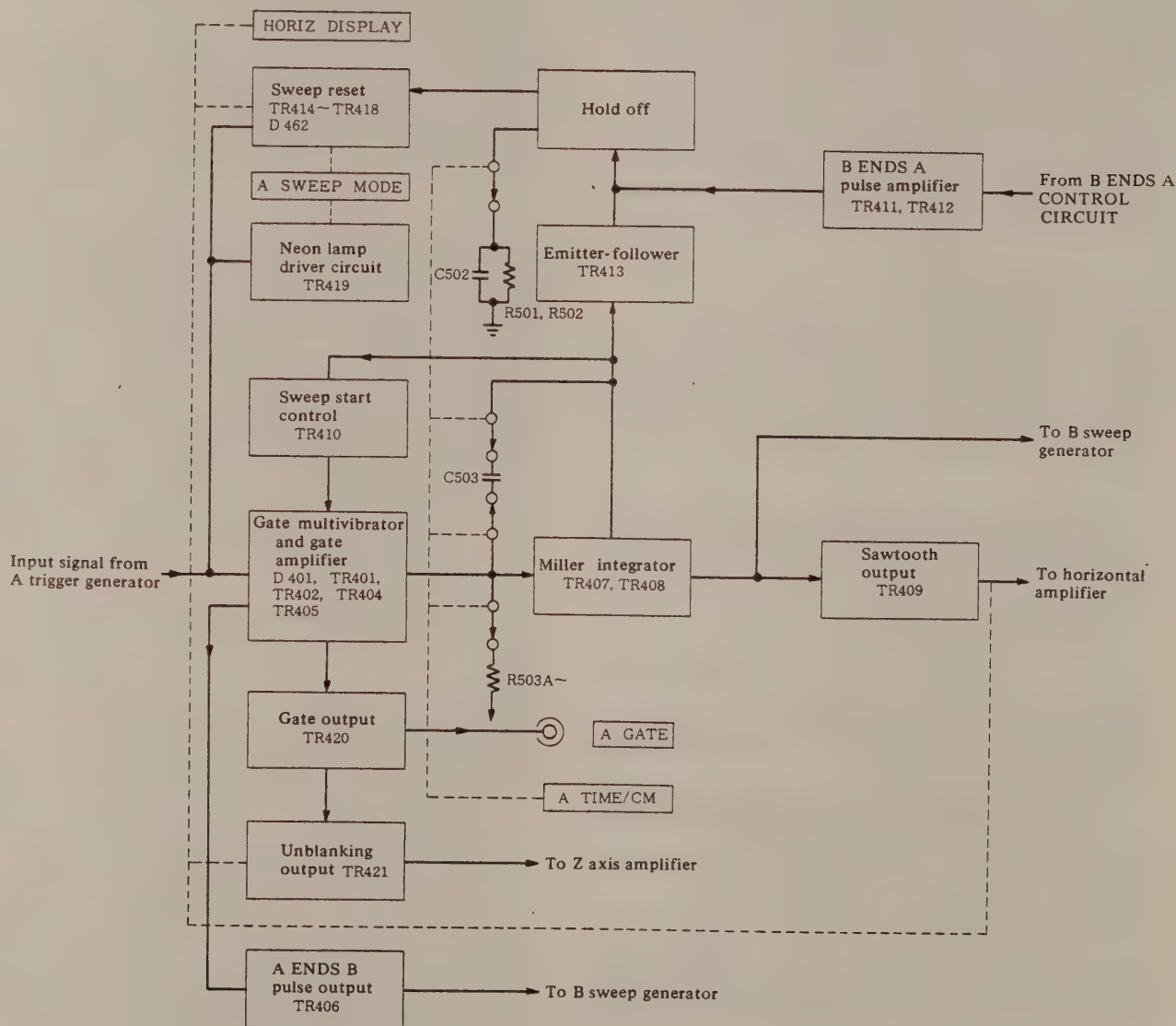
During this time, D410b continues to conduct. TR402 and TR405 compose an emitter follower and D420 is connected to the emitter of TR405, and then D420 conducts to permit the current to flow through R503A and R503B.... An amplifier composed of TR407 and TR408 is connected to the anode of D420. C503 forms a feedback circuit between the output and input of the amplifier and constitutes a Miller integration circuit. The output of the integration circuit is fed to the horizontal amplifier and B sweep generator through the sawtooth wave emitter-follower TR409, and is also given to the base of TR410 through D437. D437 conducts before the sweep starts, therefore, the input and output signal of the Miller integration circuit form a dc negative-feedback loop through TR404 — TR405 — TR407 — TR408 — D437 — TR410 — TR404. TR410 and TR404 form a comparator (Sweep start control circuit) and the base, i.e., the output potential of the Miller integration circuit is kept constant. R503A, R503B.... and C503 determine the time constant of the integration circuit. The time constant varies with the position of the A TIME/CM switch. Switching of R503 causes a variation in the input and output potential of the amplifier composed of TR407 and TR408. Due to the feedback loop, however, the output potential is held approximately constant.

The cathode of D448 is connected to the emitter of TR413, and D448 is cut off. The anode of D448 is connected to the gate of TR414, and further connected through R442 to the hold-off circuit composed of R501, 502 and C502. The source of source follower TR414 is connected to the base of TR415 and its emitter is connected through D452 to the emitter of TR417. When the MODE switch is in a position other than SINGLE TRIGGER, D458 conducts and the current flows through D458 to TR416. D459 is cut off, the base potential increases making TR415 cut off, but the collector potential is kept low. Tunnel diode D462 connected to the collector of TR415, at this time, is in the low-voltage region. On the other hand, TR418 is cut off since D462 is in the low-voltage region and its collector potential is increased. Therefore, the current corresponding to operating point C in the low-voltage region shown in Fig. 4-15 flows through R405 to the gate multivibrator D401. In this condition, when the trigger pulse is fed from the A trigger generator to D401, the current of D401 exceeds I_p and steps to point E in the high-voltage region shown in Fig. 4-15. Then TR401 conducts, the collector potential steps to negative placing D410b off. The emitter of TR402 steps to negative, following the base and the collector of TR404, to positive. When the base of TR405 steps to positive, the emitter, in

turn, also steps to positive making D420 cut off. At this time, the Miller integration circuit of TR407 and TR408 starts the integration operation with the time constant determined by R503A, R503B, ..., C503. The gate potential of TR407 starts to increase linearly (since capacitor

C503 is charged to positive through R503A, R503B, ...) and the collector voltage of TR408 decreases linearly. Therefore, D437 is turned to cut off. The base voltage of TR413 starts to decrease linearly and the emitter voltage follows. Similarly, D448 conducts, the gate voltage of

Fig. 4-14. Block diagram of A sweep generator



TR414 and the source voltage start to decrease. When the base voltage of TR415 connected to the source of TR414 starts to decrease, the collector current flows through TR415, and if the voltage reaches a certain voltage (E_1), tunnel diode D462 is shifted to the high-voltage region turning TR418 on. Therefore, the collector voltage of TR418 is stepped down, and D401 is shifted to the low-voltage region (point A in Fig. 4-15) since the forward current of tunnel diode D401 is decreased. If the trigger pulse is applied in this condition, D401 cannot move to the high-voltage region. For this reason, TR401 cuts off, the collector potential steps to positive making D401b on, and the collector voltage of TR401 is clamped to the emitter voltage of TR403 making D420 on. When D420 conducts, capacitor C503 rapidly discharges and the gate voltage of TR407 is decreased. On the other hand, the collector voltage of TR408 rapidly increases and D437 conducts. At this time, the emitter voltage of TR413 also increases similarly to the collector of TR408. Conversely, D448 is turned off since the anode potential cannot increase rapidly for the capacitive load of C502 which is charged through R450 and its voltage gradually increases. Similarly, the source voltage of TR414 and the base voltage of TR415 increase; but the current which flows through TR415 is decreased.

When the anode of D448 reaches a certain voltage (E_2), the tunnel diode D462 steps to the low-voltage region due to the current which flows through TR415. TR418 shuts off, and the forward current of D401 increases to change the operating point of the tunnel diode to point C shown in Fig. 4-15. D401 returns to its initial operating point wherein an incoming trigger pulse can drive the diode toward the high-voltage region. When TR418 shuts off, its collector voltage rises following the exponential curve of the time constant RC determined by load resistance R and stray capacitance C. To prevent this, speed-up switching is employed, i.e., when the collector voltage increases up to the voltage determined by zener diode D406, D405 con-

ducts and the increased collector voltage of TR418 is clamped. On the other hand, when the collector voltage of TR408 is increased sufficiently and D437 conducts, TR410 and TR404 are returned to the comparator region, and operate to hold the collector voltage of TR408 constant. The time in which the anode voltage of D448 increases from E_1 to E_2 is called the "hold-off time."

The hold-off time must be sufficiently longer than the time in which the collector voltage of TR408 is fully increased (sweep reset time). However, proper hold-off time is determined by selecting the values of R501, R502 and C502. One cycle of normal sweep operation ends when D401 returns to its initial operating state, and this sawtooth wave signal is fed to the horizontal amplifier through the B sweep circuit and TR409.

Auto Operation

By placing the HORIZ DISPLAY switch in any position other than CH 1 VERT CH 2 HORIZ and the A SWEEP MODE switch in the AUTO position, the A sweep generator

Fig. 4-15 Characteristic curve of tunnel diode (D401 and D701) —

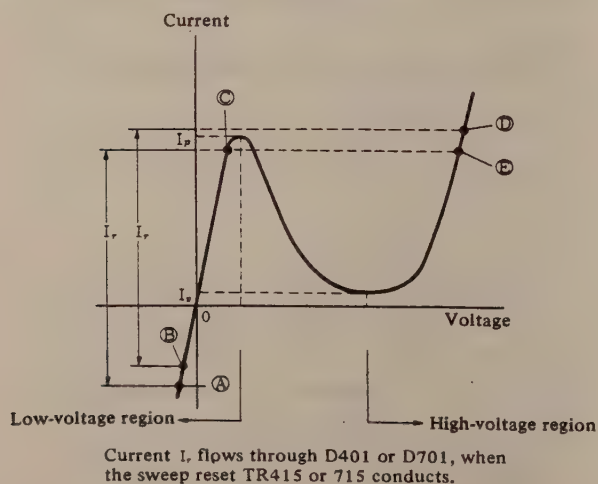
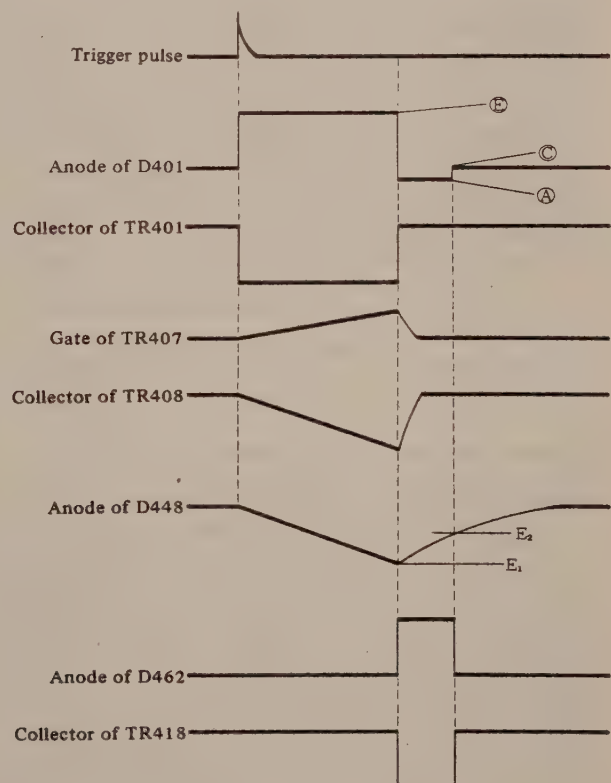


Fig. 4-16 Waveforms of normal trigger —



starts auto-triggered sweep. The AUTO triggered operation differs slightly depending on the position of the HORIZ DISPLAY switch. In order to simplify the description, the auto trigger operation will be described with the HORIZ DISPLAY switch set in the A position. As previously described under "Auto pulse amplifier and auto multivibrator," the auto trigger operation is classified into two types: trigger pulse present and trigger pulse absent. The triggered operation is similar to the normal trigger operation and automatic free-running operation. When the trigger pulse is not present, auto multivibrator TR315 in the A trigger generator is shut off, and a small amount of current flows through D325 to change the operating point of D401 from point A to B as shown in Fig. 4-15. The sweep reset transistor TR418 is cut off and a current similar to that in normal trigger operation flows through R405. When TR418 is cut off, the operating point of D401 moves to the high-voltage region (point D in Fig. 4-15) even if the trigger pulse is not present, and TR418 conducts. At the same time, the sweep operation starts. When the anode potential of D448 increases to E_2 at the end of a sweep (see Fig. 4-17), TR418 shuts off to start another sweep. Waveforms for this operation mode are shown in Fig. 4-17.

When a positive trigger pulse is applied to D401, the trigger pulse is fed to the auto pulse amplifier as described under "A trigger generator — auto pulse amplifier and auto multivibrator." This causes output transistor TR315 of the auto multivibrator to conduct, placing D325 off. There-

fore, the current which flows through D401 is the same as that of a normal trigger and the succeeding operation is also the same. However, the pulse rate becomes approximately less than 20 msec, TR315 is turned off before the next trigger pulse arrives and the sweep free-runs.

Single Sweep Operation

Single-sweep operation is possible with the HORIZ DISPLAY switch in any position other than CH 1 VERT CH 2 HORIZ. Single-sweep operation will be described herein in which the HORIZ DISPLAY switch is set to the A position. The A SWEEP MODE switch is set to the SINGLE position, the sweep generator operates as a single sweep which actuates TR416 in the sweep reset circuit and TR419 in the neon lamp driver circuit which are isolated from the normal trigger operation.

In single-sweep operation, D462 can be controlled by the single-sweep reset pulse generated by manual operation different from the NORMAL or AUTO sweep mode. Once the sweep is completed, D401 is not ready for the operation, and the sweep generator cannot be triggered even if the trigger pulse is applied since the collector voltage of TR418 does not increase unless the single-sweep reset pulse is applied to D462 from the external circuit. However, the operation is similar to that of the NORMAL sweep mode as far as the time from READY condition until the completion of sweep. Some differences in operation exist from the completion of sweep until the READY condition. Therefore, the description will start from the sweep-end condition in which the operating point of D462 is in the high-potential region, the collector voltage of TR418 is reduced, and the operating point of D401 is reverse biased (point A in Fig. 4-15) in the low-potential region. A condition wherein the trigger pulse and the reset pulse are not applied is as follows:

The gate multivibrator D401 is in the low-voltage region (point A in Fig. 4-15). TR401 shuts off and its collector voltage is increased. D420 conducts and TR404 and TR410 are in the operating range of the comparator. D448 is in the off state, and the gate potential of TR414 is not yet sufficiently increased since the hold-off capacitor is charg-

Fig. 4-17 Waveforms in AUTO sweep operation

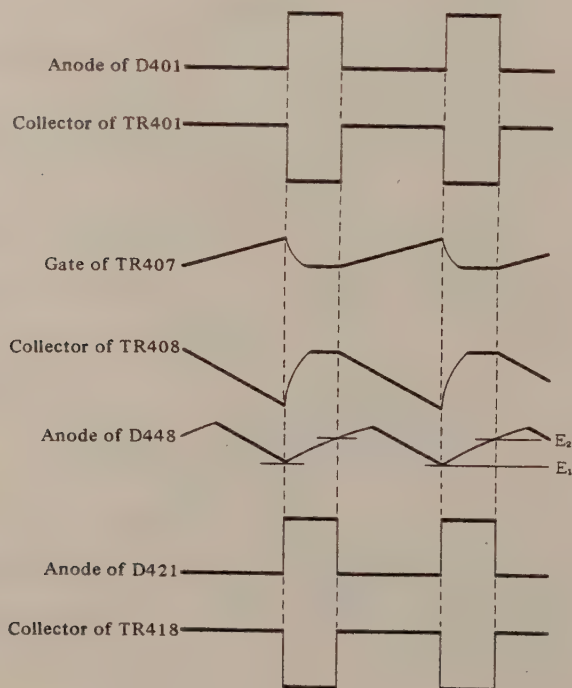
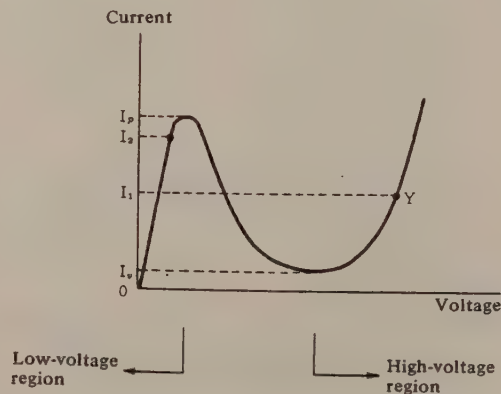
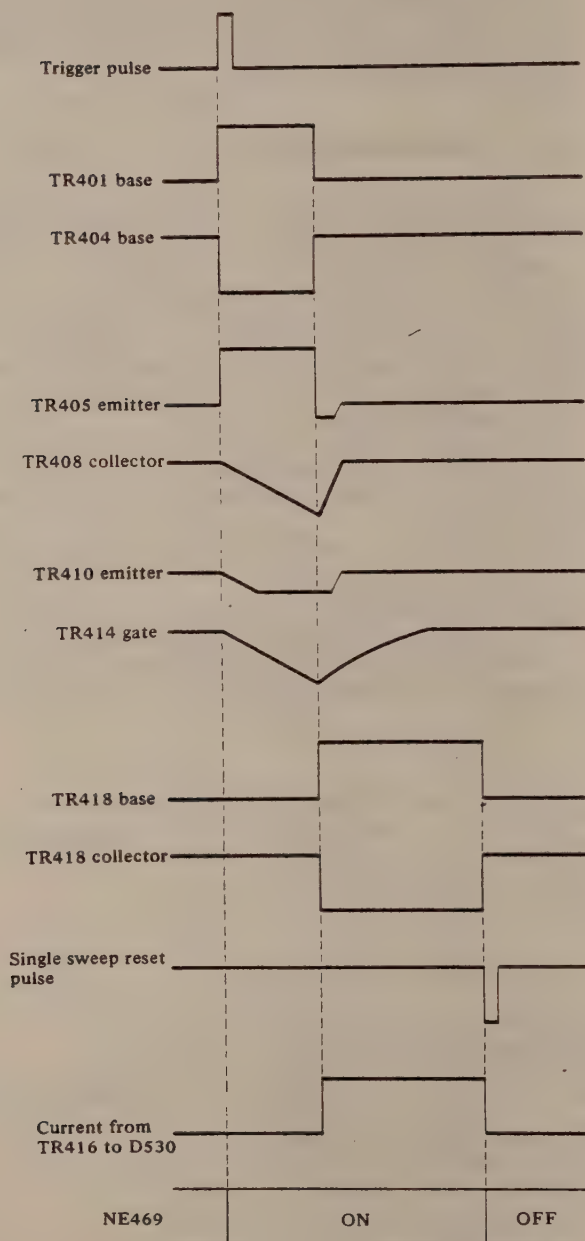


Fig. 4-18 Characteristic curve of tunnel diode (D462)



ing, and the source potential is still low. D462 is in the high-voltage region due to the low base voltage of TR415. On the other hand, considering the operation of TR416, D458, D459, and TR419 in the neon lamp driver circuit

Fig. 4-19 Waveforms in SINGLE sweep operation



when D462 steps to the high-voltage region and the sweep ends, the cathode voltage of D458 increases making D458 off and D459 conducts when the A SWEEP MODE switch is set to the SINGLE position. D467 also shuts off and the base of TR419 which has been forced into negative starts to increase. When D462 steps up to the high-voltage region and the collector voltage of TR418 is reduced, the base potential of TR416 which has been shut off is reduced to make it on and the current flows through D459 to D462. The current value takes an intermediate point between I_p and I_v of the tunnel diode D462. That is, it is indicated by I_1 as shown in Fig. 4-18. In this condition, when the voltage of the hold-off circuit, i.e., the gate potential of TR414 is increased, the collector current of TR415 is reduced. However, D462 stays at the Y position in Fig. 4-18 and cannot step to the low-voltage region since the collector current of TR416 is not reduced. Therefore, if this condition is continued, the operating point of D401 stays at point A in Fig. 4-15 and the sweep generator is not triggered by the trigger pulse, if it is applied. The base voltage of TR419 in the neon lamp driver circuit is kept low according to the collector voltage of TR418; therefore, the neon lamp NE469 connected to the collector of TR419 does not light.

Depression of the RESET switch in the B ENDS A circuit supplies a single-sweep reset pulse — a negative pulse from the collector of TR551 — to D462 through R452, and the diode jumps to the low-voltage region. The collector potential of TR418 becomes more positive causing TR416 to shut off. Then the current in D462, supplied from TR416, stops but the circuit holds this state even after the negative pulse supplied from TR462 (single sweep reset pulse) stops. The operating point of D401 is now at point C in Fig. 4-15 and the circuit is ready to be triggered by the trigger pulse. The base potential of TR419 increases to turn the transistor on, and the READY neon lamp lights.

A trigger pulse supplied to the circuit being readied for single sweep causes D401 to move into the high-voltage region (point E in Fig. 4-15), and the sweep starts. After the sweep has ended, C502 in the hold-off circuit starts to charge. In short, these operations are identical to those in the NORMAL sweep operation mode.

Gate Output and Unblanking Output

Gate Output During the sweep cycle, negative square pulse is output from the collector of TR401 to the base of TR420, and positive square pulses synchronized with the sweep frequency are output from the GATE terminal.

Unblanking Output The negative square pulses supplied to the base of TR420 produce unblanking signal in the collector of TR421. The unblanking signals (TR421 collector output) are fed to the control grid of the CRT through the Z axis amplifier. The unblanking pulse intensifies the trace during the sweep cycle. The Z axis amplifier also supplies alternate synchronization pulses (synchronized with the unblanking pulses) to the vertical axis switching circuit. Note that the unblanking pulses from A sweep generator will not be supplied to the Z axis amplifier when the HORIZ DISPLAY switch is set to the DLY'D (B) or CH 1 VERT CH 2 HORIZ position, because the anode potential of D478 becomes positive to shut off D479.

A ENDS B Pulse Output

When delayed sweep is initiated by setting the HORIZ DISPLAY switch to the A INTEN BY B or DLY'D (B) position and the A sweep ends earlier than the B sweep, the remaining portion of the B sweep is cut. The positive square-wave output of TR404 drives the base of TR406 to produce a positive signal from its emitter. The positive output of TR406 is fed through R763 to the base of TR716 to stop the B sweep after the A sweep ends.

B ENDS A Pulse Amplifier

If the B sweep ends earlier than the A sweep, in the delayed sweep operation which is actuated by setting the HORIZ DISPLAY switch to the A INTEN BY B or DLY'D (B) position, the remaining portion of the A sweep becomes unnecessary. The A sweep is forced to stop after the B sweep is ended, in the following operation.

When the HORIZ DISPLAY switch is set to the A INTEN BY B or the DLY'D (B) position, the collector potential of TR555 is alternately set to high and low-voltages by depressing the RESET switch in the B ENDS A CONTROL circuit.

The collector output of TR555 is fed to D444a in the A sweep generator and when the output is positive, D443 is turned on through diode D444a. At the end of the B sweep, a positive pulse is supplied from TR714 in the B sweep generator through R751 to the base of TR411 via the conducting diode D443. The positive pulse passes through TR411 and TR412 and produces a negative pulse at the emitter of TR412. This negative pulse lowers the cathode potential of D448b. The diode then conducts causing the gate potential of TR414 in the hold-off circuit to be lowered. As a result, a current flows D462 through TR415, D462 is set to its high-potential region, and the A sweep is stopped. (The A sweep is suspended when D462 is held in the high-potential region.)

▷ B Trigger Generator

A block diagram of the B trigger generator is shown in Fig. 4-20. This circuit makes trigger pulses which drive the B sweep generator. These trigger pulses are actuated by signals branched from the vertical deflection circuit (INT TRIG.), external trigger signals supplied to the TRIG INPUT terminal (EXT TRIG.), or by the line trigger signals supplied from the power transformer of this synchroscope.

Operation of the B trigger generator is identical to that of the A trigger generator except for the operation when the STABILITY knob in the second pulse-shaper circuit is pulled out and the auto-multi operation which is eliminated from the B trigger generator circuit.

▷ B Sweep Generator

As shown in Fig. 4-21, the configuration of the B sweep generator is basically similar to the A sweep generator.

The B sweep generator is activated when the HORIZ DISPLAY switch is set to the A INTEN BY B or DLY'D (B) position, and generates the following four signals:

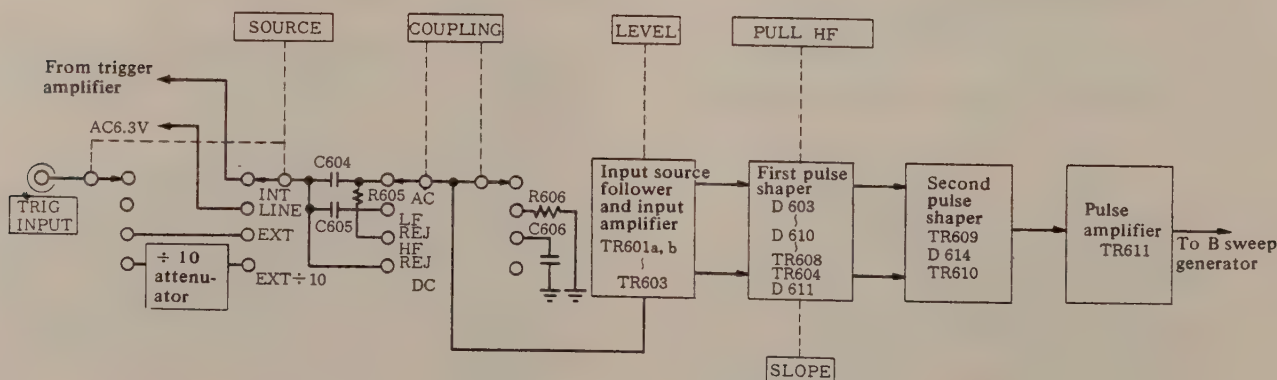
- (1) Sawtooth wave — supplied to the horizontal amplifier.
- (2) Unblanking signal — supplied to the Z axis amplifier.
- (3) Gate pulse — fed to the B GATE terminal located on the right side panel.
- (4) B ENDS A pulse — supplied to the B ENDS A pulse amplifier in the A sweep generator.

The following three signals are supplied to the B sweep generator:

- (1) Trigger pulse — supplied from the B trigger generator.
- (2) A sweep signal — supplied from the Miller integrator in the A sweep generator.
- (3) A ENDS B pulse — supplied from the A ENDS B pulse output circuit in the A sweep generator.

The B sweep generator generates signals to control the delayed sweep operation (A INTEN BY B or DLY'D (B)),

Fig. 4-20 Block Diagram of B Trigger Generator



and the B sweep always starts later than the A sweep. Operation of the B sweep generator is basically similar to the single-sweep operation in the A sweep generator. The pulse which is equivalent to the SINGLE SWEEP RESET pulse in the A sweep generator is the DLY'D TRIG pulse generated by the DELAY PICKOFF circuit in the B sweep generator.

In order to start the B sweep, D761 must be held in its low-potential region. Thus, the B sweep is suspended by turning the diode to its high-potential region. The B sweep generator is controlled by turning the diode to the high or low-potential region.

A INTEN BY B Operation

Negative sawtooth waves are supplied to the input circuit

of DELAY PICKOFF pulse generator, i.e. the base of TR720 through R773 from the A sweep circuit. TR720 composes a voltage comparator. When the sawtooth wave level reaches a certain potential (namely E3), the left half of TR720 conducts and the right half shuts off. Tunnel diode D776 steps into the high-potential region causing the base of TR721 to step to positive potential. The collector potential of TR721 drops, and a negative pulse is output. The timing to output the negative pulse (delay pickoff pulse) is variable with the DELAY TIME MULTI R769. The delay pickoff pulse is supplied to the anode of D761. Diodes D772a and b connected to the emitter circuit of TR720 absorb the reverse bias voltage across the base and emitter of TR720 to prevent breakdown of the comparator.

When D761 is held in its high-potential region, the collector of TR715 is retained in low potential causing TR712 to conduct. Thus, the diode D761 is held in the

Fig. 4-21 Block Diagram of B Sweep Generator

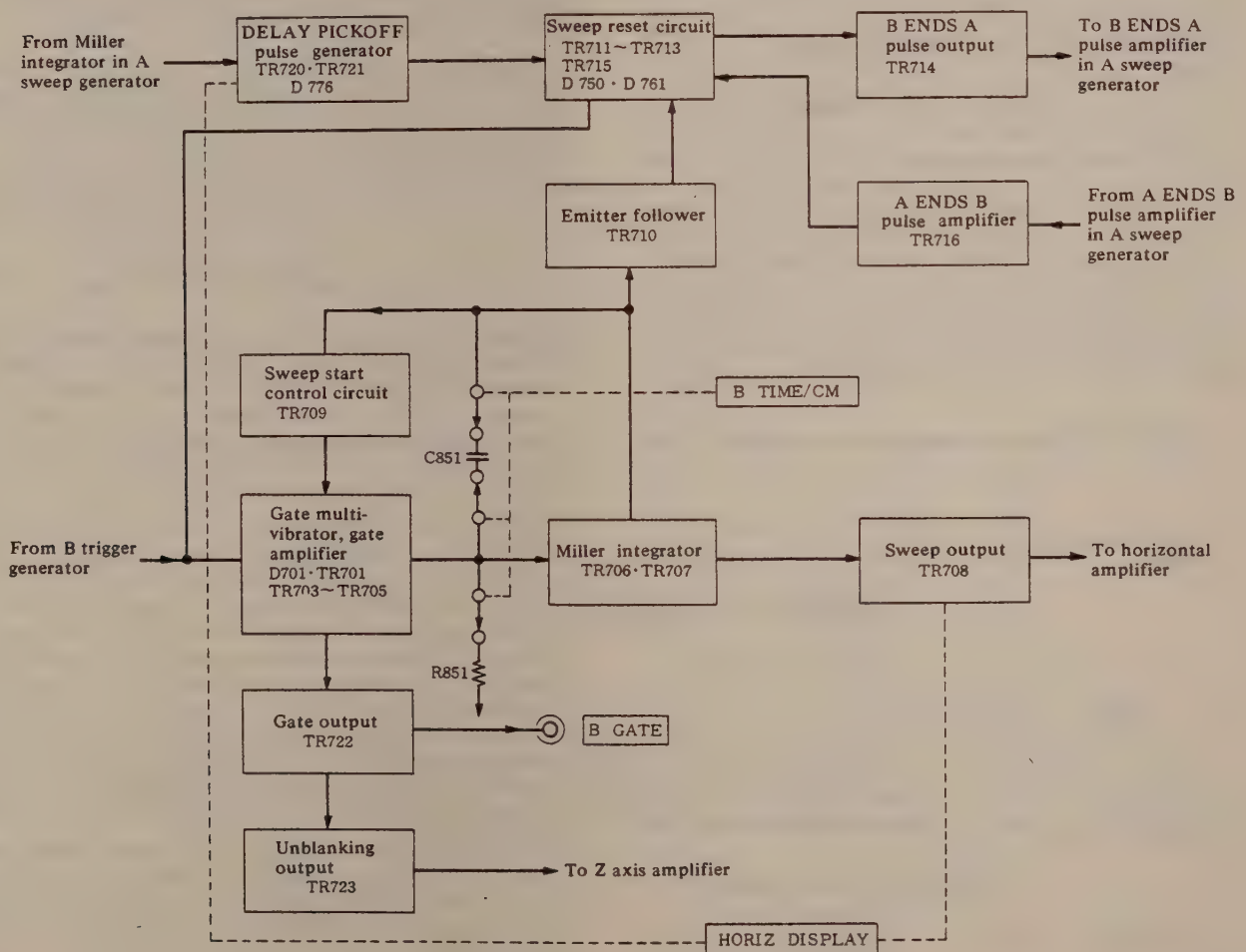
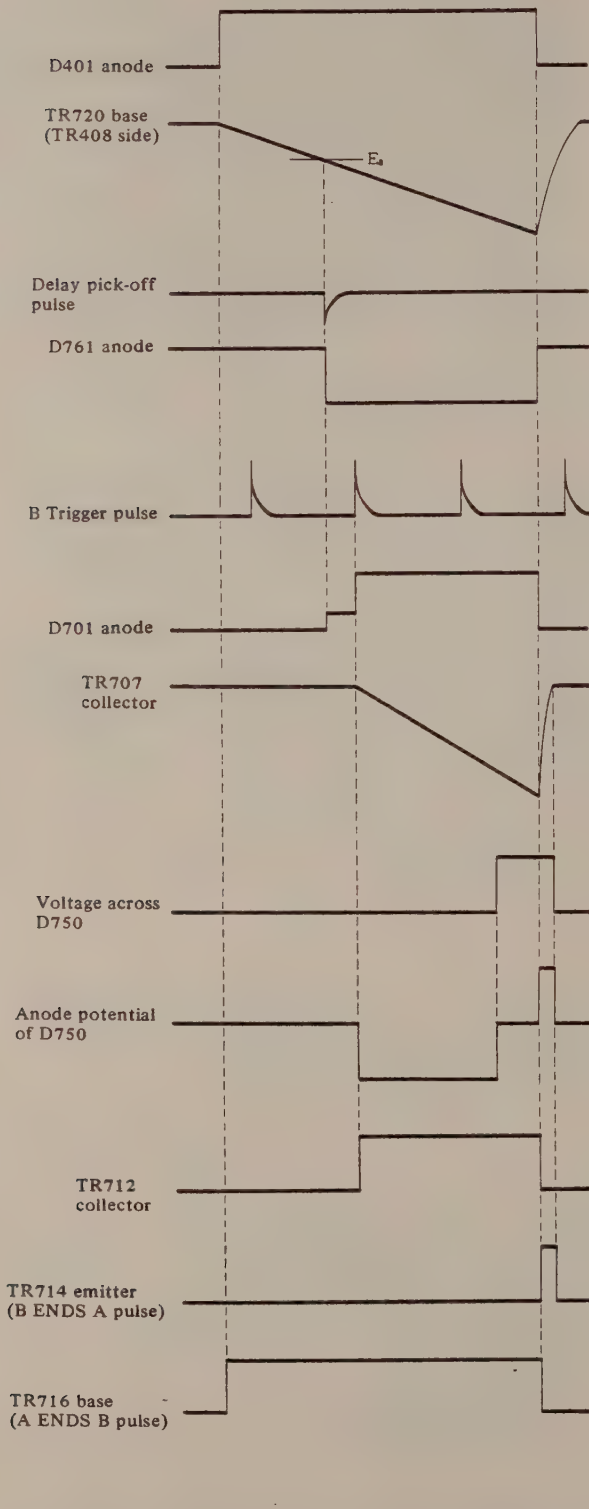


Fig. 4-22 Waveforms in A INTEN BY B Operation



position even after the current applied from TR711 through D750 stops. The delay pickoff pulse supplied to D761 during this sequence causes the tunnel diode to step to the low-potential region. It causes the collector potential of TR715 to step more positive, the operating point of D701 steps to point C in Fig. 4-15, and the B sweep generator is reset.

When a trigger pulse is fed from the B trigger generator, the B sweep generator starts to sweep. After one sweep cycle is completed, D701 returns to point A in Fig. 4-15, and the B sweep generator cannot reset until the next delay pickoff pulse is supplied. (These sequences are identical to the single-sweep operation of the A sweep generator.) The Triggered operation is initiated by turning the DLY'D (B) MODE switch to the TRIG'D position. The Non-Triggered operation which is started by turning the DLY'D (B) MODE switch to the AUTO position is described in the following. In this mode, the bias voltage of D701 is selected so that the operating point of the diode will turn above point C (larger than I_p) in Fig. 4-15 simultaneously with the end of the sweep (when D761 steps to the low-potential region and TR715 is shut off). In this case, the B sweep generator repeats sweeping, initiated by the delay pickoff pulses independently from the trigger pulse input.

A ENDS B Operation While the A sweep signal is generated, in the A INTEN BY B operation, a positive square wave (A ENDS B pulse) is supplied to the base of TR716 from the emitter of TR406, as shown in Fig. 4-22. TR716 is held shut off and its collector potential drops while the signal is supplied, i.e. during the A sweep cycle. At the end of the A sweep, TR716 conducts, the collector potential increases and D761 steps into the high-potential region, if it has been kept in the low-potential region. The B sweep ends simultaneously with the end of the A sweep.

B ENDS A Operation The B ENDS A operation is started by depressing the RESET button while the circuit is operating in the A INTEN BY B mode. The B ENDS A operation can be reset by depressing the button again. In the B ENDS A operation, the A sweep is forced to terminate with the end of the B sweep. When the B sweep ends earlier than the A sweep, the remaining portion of the A sweep signal is insignificant. Thus, it is advantageous to suspend the remaining A sweep to increase possible repetition frequency of the sweep operation. Also it reduces flickering of the display and increases CRT intensity. The B ENDS A pulse (positive pulse) is supplied at the end of the B sweep, from the emitter of TR714 to the A sweep generator circuit to end the A sweep. The negative going sawtooth wave generator in the B sweep Miller integrator is supplied to the base of TR711 through TR710. As the base potential of TR711 is lowered with the increase of negative sawtooth wave amplitude, the collector current of TR711 flowing through D750 and D761 increases gradually. Diodes D750 and D761 are connected in series, but a larger current (I_p) flows D761 than in D750.

D750 steps into its high-potential region earlier than D761 (to higher potential region) before the end of the B sweep. After the B sweep ends, a current is continuously supplied to D761 through TR712, and the diode is held in the high-potential region until the next delay pickoff pulse is supplied.

The collector current in TR711 decreases at the end of the B sweep, and D750 steps into the low-potential region.

In this way, D761 steps into the high-potential region simultaneously with the end of the B sweep, but D750 remains in the high-potential region for a short period after the end of the B sweep (due to a small time lag required for recovery of the Miller integrator). The time lag in the recovery of two tunnel diodes produces a positive potential at the anode of D750 as shown in Fig. 4-21, and a positive pulse is output from the emitter of TR714. For the B ENDS A operation, also refer to the appropriate B ENDS A pulse amplifier and the B ENDS A control circuit which will be described later.

During the A INTEN BY B operation, sawtooth signals from the A sweep generator are supplied to the horizontal amplifier, while the sum of A and B unblanking signals are supplied to the Z axis amplifier. Thus, the portion of the trace which corresponds to the B sweep is much more intensified.

Delayed Sweep Operation [DLY'D (B)]

The DLY'D (B) operation is basically identical to the A INTEN BY B operation. When the circuit is set to the DLY'D (B) operation, sawtooth signals from the B sweep generator are supplied to the horizontal amplifier, and the unblanking signals are also supplied from the B sweep generator to Z axis amplifier. In this operation, therefore, the more brightened portion of the sweep in A INTEN BY B operation is displayed with a time delay by an amount equal to the A sweep part preceding the B sweep in the A INTEN BY B operation.

▷ B ENDS A Control Circuit

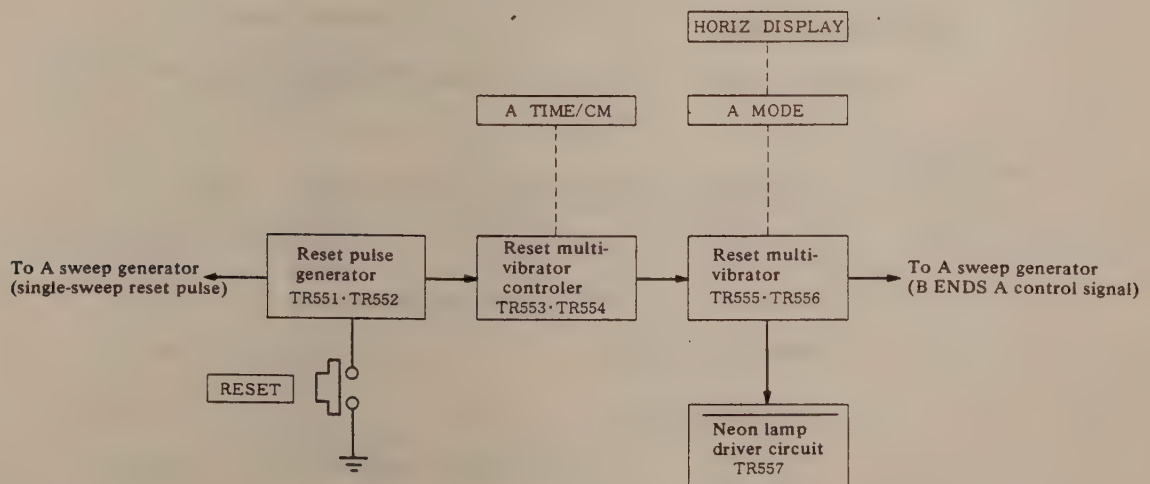
A block diagram of the B ENDS A control circuit is shown in Fig. 4-23. The following two signals are generated in this circuit by depressing the RESET button.

- (1) Single-sweep reset pulse — This pulse is required for the A sweep generator in single sweep operation.
- (2) B ENDS A control signal — This signal (a change in dc level) controls the B ENDS A pulse supplies to the hold-off circuit in A sweep generator.

The reset pulse generator is a type of monostable multivibrator which generates the single-sweep reset signal and the reset pulse supplied to the reset multivibrator (the latter pulse initiates or releases the B ENDS A operation). In the stationary state, TR551 is held shut off, and its collector potential is maintained at +12 V. This causes TR552 to shut off, and the collector potential of TR552 and the potential at the positive side of C553 are set to 0 V. Depression of the RESET button causes the negative charge in capacitors C550 and C551 to be discharged, thus supplying a positive pulse to the base of TR551 via D552. TR551 then conducts, and a decrease of its collector potential turns TR552 on. The base potential of TR551 increases through R554 and C553, and TR551 is held in conduction after the positive pulse from TR552 stops. The base current applied to TR551 through C553 saturates and the capacitor starts to discharge. The base potential of TR551 is lowered gradually until TR551 is shut off causing TR552 to shut off also. In this way, the collector of TR551 steps toward low potential and a negative pulse is generated through C557. The negative pulse (single-sweep reset pulse) is fed to the A sweep generator. When TR552 steps to conduct, its collector goes to positive potential, and a differentiated positive pulse is supplied to the base of TR553.

In its stationary state, the reset multi control, TR553 and 554, is saturating since the base potential of TR553 is held lower than the emitter potential. When the positive pulse is supplied through C554, TR553 is shut off during the duration of the pulse, and a negative pulse is supplied from its collector to the reset multivibrator composed of TR555 and TR556. The emitters and collectors of TR553 and TR554 are connected in parallel, therefore, the emitter and collector of TR553 are short-circuited when TR554

Fig. 4-23 Block Diagram of B ENDS A control circuit



conducts. The base of TR554 is connected to the A TIME/CM switch via D566. When the switch is set to any position in the 0.1 to 5 SEC/CM range, the cathode of D566 is connected to the -12 V line, and TR554 conducts. This means that the drive pulse will not be supplied to the reset multivibrator, TR555 and TR556, even when the RESET button is depressed with the A TIME/CM switch in this position.

The reset multivibrator TR555 and TR556 forms a stable multivibrator. TR555 is shut off and TR556 conducts whenever the power switch is turned on. Capacitor C563 connected to the base circuit of TR556 produces a time lag between the reverse bias voltages to be supplied to TR555 and TR556.

Depression of the RESET button supplies a negative pulse, through TR553, to the reset multivibrator, thus TR555 turns on and TR556 is shut off, and the multivibrator is held in the other stable state. A further depression of the RESET button changes the state of the multivibrator. The collector of TR555 is connected to D444a in the A sweep generator, thus, the conduction of TR555, i.e. increase of its collector potential, causes D444a to conduct followed by the conduction of D443. The B ENDS A pulse supplied from the B sweep generator (refer to Fig. 4-22) reaches to the base of TR411 through D443. The A sweep generator starts the B ENDS A operation. When TR555 is shut off, diodes D443 and D444a are both shut off, thus, the B ENDS A operation is prohibited.

In this manner the level variation at the collector of TR555 is transferred to D444a. Operation of the reset multivibrator depends upon the position of the HORIZ DISPLAY switch or A MODE switch. When the HORIZ DISPLAY switch is set to A or CH 1 VERT CH 2 HORIZ positions $+12$ V line is connected to the emitters of TR555 and TR556, therefore TR555 and TR556 are not turned over by the negative pulse sent from TR553 and the collector level of TR555 remains unchanged. When the A

MODE switch is changed from the AUTO or NORM position to the SINGLE mode, $+12$ V line is fed to the emitters of TR555 and TR556 through D563. If TR556 is conducting (the initial state when the POWER switch is turned ON or by depression of the RESET button), TR556 is not turned over by the pulse from TR553, holding the collector level of the TR555 unchanged. When the MODE switch is changed to the SINGLE mode, TR556 is not turned over by the negative pulse fed from TR553 if TR556 is turned off (turned over once by depressing the RESET button from the initial ON state with the POWER switch). However, TR556 is off, or TR555 is on, holding the increased collector potential of TR555. Both D443 and D444a conduct enabling the B ENDS A operation by means of SINGLE sweep.

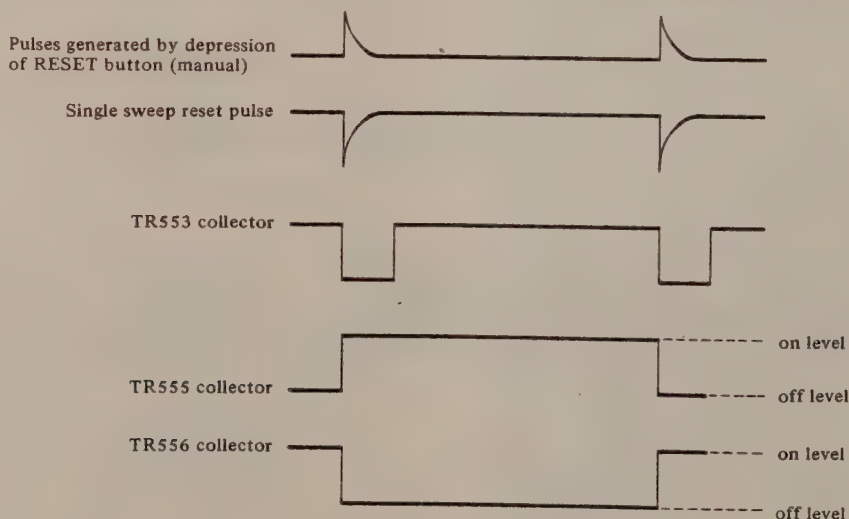
When TR555 is turned on, the base potential of TR557 increases, while the collector potential decreases, and the neon lamp NE564 lights indicating that the B ENDS A operation is in progress.

When the TIME/CM switch for A sweep is set in the range of 0.1 – 5 SEC/CM, TR554 conducts, preventing the collector of TR553 from sending negative pulses to the reset multivibrator. The reset multivibrator is not reversed and the B ENDS A operation is in effective. If the A TIME/CM switch is sent to a range other than 0.1 – 5 SEC/CM, the reset multivibrator is maintained in the original state and the B ENDS A operation is initiated by the negative pulses from TR553. The B ENDS A operation is prohibited within the 0.1 – 5 SEC range through the A TIME/CM switch because the hold-off period in the A sweep circuit is prolonged in this range and B ENDS A operation is not stabilized.

▷ Horizontal Amplifier

A block diagram of the horizontal amplifier is illustrated

Fig. 4-24 B ENDS A Control Circuit Waveforms



in Fig. 4-25. A sawtooth waves, B sawtooth waves, or external horizontal signals are amplified up to a level to deflect the electron beam of the CRT horizontally.

When the HORIZ DISPLAY switch is placed in the A position or A INTEN BY B A sawtooth waves are supplied, and B sawtooth waves are supplied when it is set to the DLY'D B position. When the HORIZ DISPLAY switch is set to the CH 1 VERT CH 2 HORIZ, the input signals of the CH 2 INPUT are supplied through the trigger amplifier.

1st Stage Amplifier

Each sawtooth wave generated by the A and B sawtooth generator is supplied to the base of TR1003 and converted into a symmetrical signal to be fed to the 2nd stage amplifier by the collectors of TR1004 and TR1005. The amplifier is applied with negative feedback, resulting in improved frequency response characteristics. The base potential of TR1003 is varied by variable resistor R107a · b for horizontal adjustment of the electron beam. Variable resistor R1026 is used for adjusting the NORM GAIN, and R1030 for the MAG GAIN. By pulling the FINE control for the HORIZ POSITION, it is set in the PULL x 10 MAG state, where the current flows to RL1001.

R1030 is inserted into the circuit and the gain of amplifier is increased by ten times.

External Horizontal Signal Amplifier

When the HORIZ DISPLAY switch is set to CH 1 VERT CH 2 HORIZ position, the input signal fed to the INPUT of CH 2 is applied to the base of TR1001 through the collector circuit of TR280 in the trigger amplifier. Variable resistor R1001 adjusts the amplitude of the input signal which is fed to the base of TR1003 through the collector circuit. Variable resistor R1006 and coil L1001 are used in

XY scope operation to match the phase with that of the Y signal.

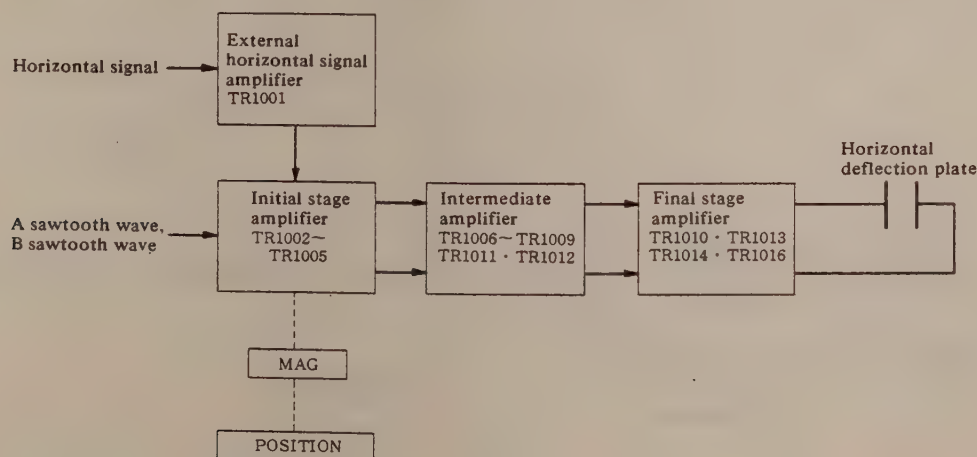
Intermediate Amplifier

The balanced signal through TR1004 and TR1005 is fed to the base of emitter-follower TR1006 and TR1007 and to the base of TR1010 and TR1013 through the collectors of TR1008 and TR1009. D1005 and D1007 keep TR1008 and TR1009 from saturation (especially for MAG x 10). The base potential of TR1011 and TR1012 is maintained at a certain value and serves as a constant power source to prevent variation of the emitters of TR1011 and TR1012. RL1002 functions for the maximum sweep time only, that is, when the HORIZ DISPLAY switch is set to the A, A INTEN BY B or DLY'D (B) position, or when the A TIME/CM or B TIME/CM switch is placed in the 10 nsec range. R1042 and C1023 · C1024 are inserted to improve the high-frequency response characteristics for maximum sweep.

Final Stage Amplifier

The final stage amplifier consists of two feedback amplifiers, one composed of emitter-follower TR1010 comprising a PNP transistor, TR1014 comprising the PNP transistor, and its feedback circuit. The other amplifier is composed of emitter-follower TR1013 comprising a NPN transistor, TR1016 comprising the NPN transistor and its feedback circuit. When the balance signal is applied to these two feedback amplifiers, both operate toward the direction to turn them on. The PNP or NPN transistor is optional to comply with the fast sweep characteristics. The emitter-follower TR1010 and TR1013 drives TR1014 and TR1016 with low impedance. TR1014 and TR1016 amplify the balanced signal, which is fed to the horizontal deflection

Fig. 4-25 Block Diagram of Horizontal Amplifier



plates of the CRT. D1015 and D1016 prevent delay of the feedback time due to the saturation of TR1014 and TR1016. D1017 and D1023 are used to adjust the dc level.

▷ Z Amplifier

The circuit configuration of the Z amplifier is shown in Fig. 4-26. This amplifier operates to maintain the intensity on the CRT graticule at the proper brightness. Specifically, it amplifies the unblanking signal to erase the sweep intensity by illuminating the trace, to amplify the chop blanking signal to cancel the transient for the CHOP sweep, to amplify the signal which modulates the external intensity to be applied to the Z AXIS INPUT, or selects the voltage to adjust the intensity by operating the INTENSITY switch. The unblanking signal is also converted into a pulse to serve as the alternate sync pulse.

Input Amplifier

The base of TR1100 is AC grounded with very low input impedance, and the collector is driven by the current. The negative-going unblanking signal applied to the emitter of TR1100 is current amplified and fed to TR1104 and TR1105. The transient current produced during chopped sweep operation is fed to the emitter of grounded base transistor TR1101 in the form of a positive pulse, the collector is driven by the positive current. The external intensity modulation signal to be applied to the Z AXIS INPUT connector and the level variation due to INTENSITY control adjustment are also provided from the emitter of TR1101.

The high frequency component of the external intensity modulation signal applied to the Z AXIS INPUT connector is also directed to the cathode of the CRT via capacitor C1264.

ALTERNATE SYNC Pulse Amplifier

The unblanking signal from the sweep circuit is applied to the emitter of transistor TR1100 and the base of transistor TR1102, to be differentiated by the pulse transformer T1100. Upon termination of the unblanking signal, only the positive pulses synchronized with termination of the sweep are applied to the base of transistor TR1103. Transistor TR1103 sends these pulses to TR21 via C102 of the vertical switching circuit as the alternate sync pulses with low impedance.

Output Amplifier

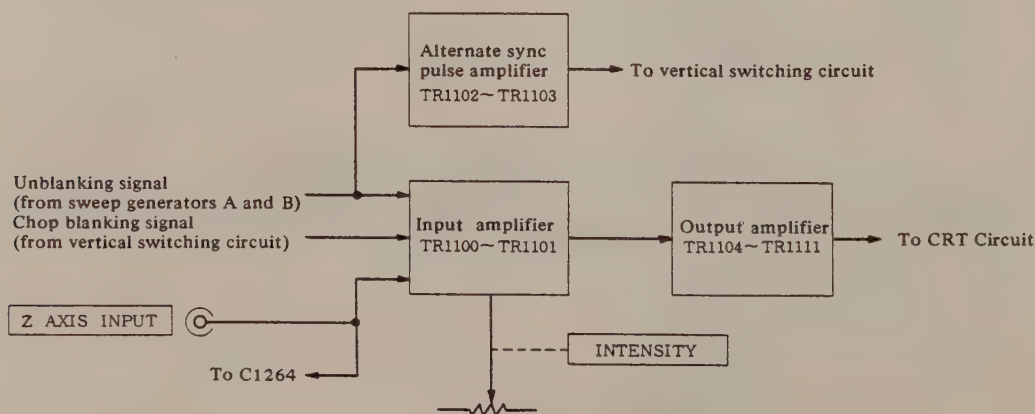
The output amplifier comprises two negative-feedback type amplifiers, one of which consists of PNP transistors TR1104 and TR1106 to TR1110 and the other is composed of NPN transistors TR1105 and TR1111. When input is applied, one of the two amplifiers turns on, to accelerate the pulse response speed.

Assuming that the collector of transistor TR1100 is being driven by the negative pulse, transistors TR1104 and TR1106 (AC-coupled) turn on, causing transistors TR1107 through TR1110 to turn on. In this manner, positive pulses with fast rise times are obtained at the collector of TR1110. Transistors TR1105 and TR1111, on the other hand, turn off, obtaining positive pulses of which the rise time slightly lags at the collector of TR1111. Subsequently, transistors TR1104 through TR1110 operate for the fast rising portion of the pulse and TR1105 and TR1111 for the flat portion. When the negative input pulse regains its original level, TR1105 and TR1111 conduct and the collector of TR1111 rapidly returns to its initial state.

Description is omitted for the operation when the collector of TR1100 is driven by positive pulses, since operation of the two amplifiers is simply reversed.

Negative feedback is carried out by resistors R1115 and R1116 from TR1110 and TR1111 to TR1104 and TR1105, to improve the characteristics. The circuitry design also

Fig. 4-26 Block Diagram for Z-Amplifier



reduces the voltage applied to individual transistors by connecting transistors TR1106 through TR1110 in series.

The outputs of the output amplifier are fed to the CRT circuit from the collectors of TR1110 and TR1111; the unblanking signal as the positive, and the chop blanking signal as the negative signals respectively.

► CRT Circuit

Fig. 4-27 shows the configuration of the CRT circuit, which provides high voltage to emit and accelerate the electron beam. The high voltage is obtained by converting the unregulated power (approx. 30 V) from the low voltage into approximately 30 kHz sine wave by the high-voltage oscillator. The sine wave voltage is further increased by the high-voltage transformer T1201 and rectified.

High-Voltage Oscillator and High-Voltage Control Circuit

The high-voltage oscillator comprises transistor TR1201 and transformer T1201. The base and collector of transistor TR1201 are connected with the base winding and collector winding of transformer T1201, respectively, to

form a back-coupled oscillator. Class C TR1201 is useful.

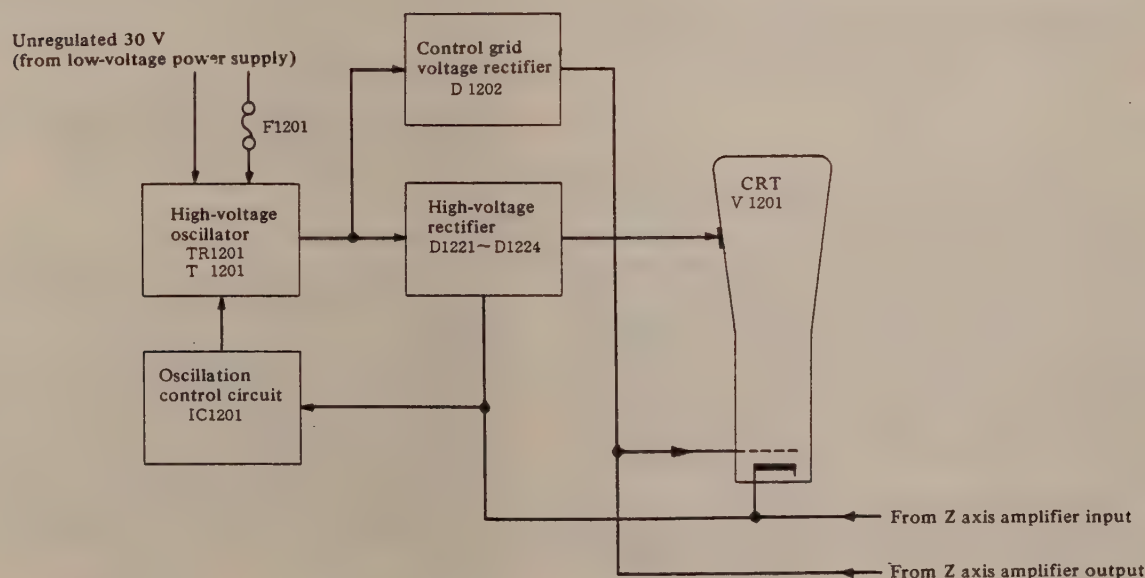
The oscillation control circuit feeds back a portion of the output voltage from the secondary circuit to the high-voltage oscillator and controls the oscillation level of the high-voltage oscillator so that the output voltage rectified at the secondary circuit of T1201 will be held constant.

Consider a case wherein a variation in the load has caused the CRT cathode voltage to decrease. The variation in cathode voltage is let to the input terminal of IC1201 in which the voltage is compared with the reference voltage. Error voltage from the comparator is amplified in IC1201 and consequently increases the base current of TR1201. This causes the collector current of TR1201 to increase, and the oscillation is intensified until the output cathode voltage recovers the initial voltage. Variable resistor HV ADJ 1201 controls the base potential of TR1201 through IC1201. This is a manual control for oscillation intensity.

Control Grid Voltage Rectifier

A negative 2500 V is supplied from the control grid voltage rectifier to the control grid of the CRT. A high ac voltage across terminals 5 and 6 is half-wave rectified in the circuit composed of C1206, C1207, D1202, terminal 5 and

Fig. 4-27 Block Diagram of CRT Circuit



terminal 6, and the rectified dc output is supplied to the control grid of the CRT.

Neon tubes NE1201 and NE1202 conduct when an irregular voltage is supplied across the cathode and control grid of the CRT. These neon tubes protect the CRT.

High-Voltage Rectifier

The high-voltage rectifier supplies an acceleration voltage of +13.5 kV to the accelerator and -2450 V to the cathode of the CRT.

The high voltage, +13.5 kV is produced by a voltage quadrupler composed of diodes D1221 through D1224 and capacitors C1221 through C1225 which rectifies the ac voltage across terminals 7 and 9 of T1201.

The cathode voltage is a half-wave rectified output, by C1210 and D1203, of the voltage across terminals No. 7 and No. 8.

Variable resistor R1211 changes the dc potential of terminal No. 7 and adjusts the cathode voltage relative to the control grid. This control is used to change intensity of spot.

Connection to Z Axis Amplifier

The output signal from the Z axis amplifier is supplied to the control grid of the CRT, through C1262 and C1263, in order to modulate the intensity of the CRT.

▷ Low-Voltage Power Supply

Configuration of the low-voltage power supply circuit is shown in Fig. 4-28. The circuit supplies various dc voltages to the internal circuits of the synchroscope.

Input Circuit

Line voltage is supplied to the primary winding of power transformer T1301 through fuse F1342, power switch S1342, LINE VOLTAGE RANGE switch, S1343 and THERMO CUTOUT S1341. To use this instrument on a 100 V AC line, two primary windings of the transformer T1301 are connected in parallel. By setting the LINE VOLTAGE RANGE switch to the 100 V position, the windings between terminals 1 and 2 and, terminals 3 and 4 are connected in parallel, and when the switch is set to the 115 V position, terminals 1 - 4 and 3 - 6 are connected in parallel, respectively. When using the synchroscope on a 200 V AC line, two primary windings are connected in series.

The THERMO CUTOUT S1341 automatically trips if the temperature inside the synchroscope increases abnormally. It resets automatically when the temperature falls to a safe level.

-12 V Supply

The -12 V power supply is used for the reference voltage of other power supplies. The secondary voltage

(terminals 9 and 10) of T1301 is rectified by the diode bridge from D1322a to D1322d and smoothed by capacitor C1324. The output voltage is voltage regulated by the series regulator TR1321 whose internal resistance is controlled by the IC module IC1321.

Variation in the -12 V output, due to load variations etc., is detected by IC1321 and fed back through TR1322 to the base of TR1321 until the output voltage recovers the initial level. In this way, the output voltage is held at a constant -12 V and ripple voltage in the output is minimized. The output voltage is controlled by variable resistor R1324.

+12 V Power Supply

The voltage rectified by bridge rectifier from D1302a to D1302d is filtered by capacitor C1303 and is supplied to the series regulator TR1301. The reference voltage is supplied to IC1301 from the regulated -12 V supply. Similar to the -12 V power supply, variation in output of the +12 V circuit is fed back to the base of TR1302 from C1302 through TR1302 in order to regulate the output voltage level. The output voltage is controlled by variable resistor R1306.

Low-Voltage Supply for High-Voltage Oscillator

The dc voltage rectified by D1323 and filtered by C1325 is connected on one end to the +12 V line, and a total of +30 V is supplied to the high-voltage oscillator.

+27 V Power Supply

A dc voltage rectified by D1401 and filtered by C1381b is supplied to the series regulator TR1401. IC1401 and TR1401 compose a regulated power supply.

+50 V Power Supply

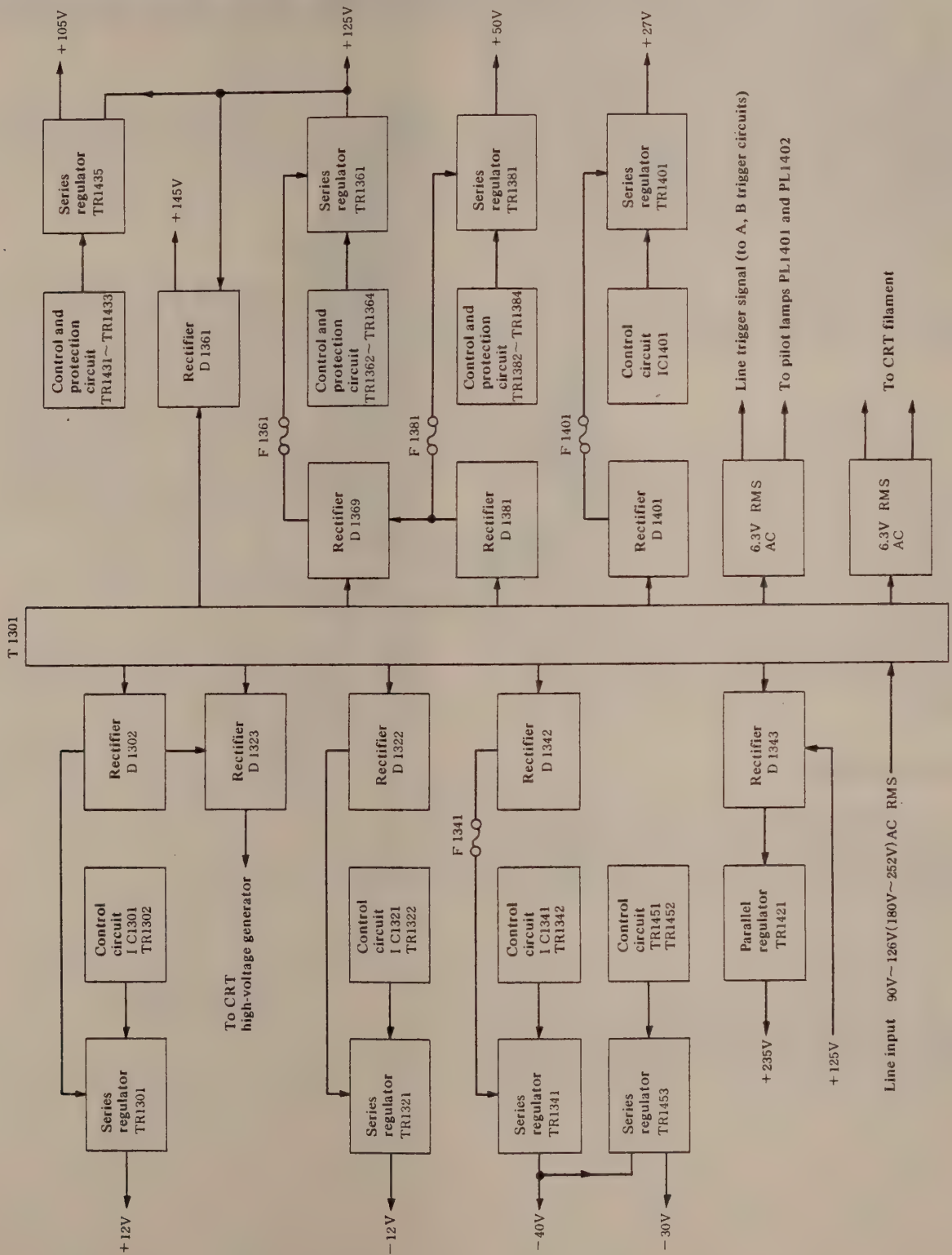
A dc voltage rectified by a bridge rectifier D1381a to d is filtered by C1381a and supplied to the series regulator TR1381.

Variation in the output voltage is fed to the base of TR1384, and then to the base of TR1381 through TR1382 to regulate the output level. TR1383 functions to protect the power supply against overload. If the output current increases excessively, TR1383 turns on to lower the base current of TR1382, and consequently the base current of TR1381 is also reduced to limit the output current. Variable resistor R1388 controls the output voltage.

+125 V Power Supply

The dc voltage rectified by a diode bridge D1369a to d and filtered by C1362 is connected to the positive line of the +50 V power supply. This voltage is also supplied to the series regulator TR1361 where it is regulated. Overload protection is accomplished by TR1363.

Fig. 4-28 Block Diagram of Low-Voltage Power Supply



+105 V Power Supply

The +105 V power is produced from the +125 V power supply. The series regulator TR1435 is connected to the +125 V line and obtained +105 V from the emitter. Variation in the -105 V output is detected by TR1432, and fed to the base of TR1435 through TR1432 and TR1433 to maintain the output voltage at a constant value. TR1431 is a overcurrent protector and variable resistor R1439 controls the output voltage level. Refer to "Low-Voltage Power Supply" in Chapter 6, Calibration.

+145 V Power Supply

A dc voltage rectified by D1361 and filtered by C1361 is connected to the +125 V power supply, and forms the +145 V power supply.

+235 V Power Supply

AC voltage across terminals 15 and 16 of T1301 is rectified by diode bridge composed of D1343 a to d and filtered by C1345. The rectified dc voltage is connected to the +125 V line to form the +235 V power which is supplied through R1421. TR1421 is a parallel regulator. Variation in the load current, should it tend to increase, changes the output voltage and the voltage drop across R1349. The former decreases and the latter increases, in this example. The increased voltage drop across R1349 lowers the base potential of TR1421 causing its collector current to become less, and consequently it compensates for the increased load current. Increase in the output voltage is similarly compensated by reversed operation of this circuit.

-40 V Power Supply

A dc voltage rectified by D1342 and filtered by C1344 is supplied to the series regulator TR1341. The reference voltage is supplied from the -12 V source to IC1341. Similar to the -12 V power supply, the output voltage of this circuit is regulated by IC1341, TR1342 and the series regulator TR1341.

-30 V Power Supply

The -30 V power is supplied from the -40 V power supply. The -40 V is supplied to series regulator TR1453, and a -30 V dc is made from the collector. Output voltage of this circuit is controlled by the variable resistor R1455.

Refer to "Low-Voltage Power Supply" in Chapter 6, Calibration.

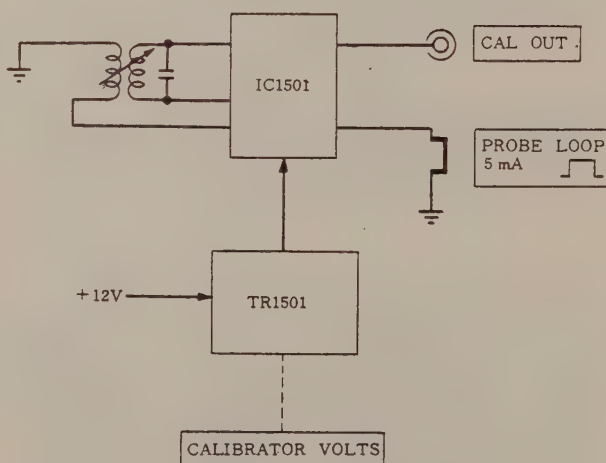
6.3 V AC Power Supply

Two ac power supplies (6.3 V rms) are provided, one is given to the CRT filament and other to scale illumination lamps PL1401 and 1402 and to the A and B trigger circuit as the line trigger signal.

► Calibrator

As shown in Fig. 4-29, the 1 kHz square-wave voltage and current are generated in the calibrator circuit. The oscillator is composed of an IC module IC1501 and a transformer T1501. The oscillation frequency is determined by the transformer inductance and capacitor C1501. Output level of the calibrator is variable by the potentiometer R1503 which changes the base potential of TR1501 and consequently changes the voltage level supplied to the IC module. Square-wave output current from IC1501 flows to resistors determined by the position of the CALIBRATOR VOLTS switch. A square-wave current of 5 milliamperes flows through the PROBE LOOP and the calibrator voltage is supplied to the CAL OUT connector.

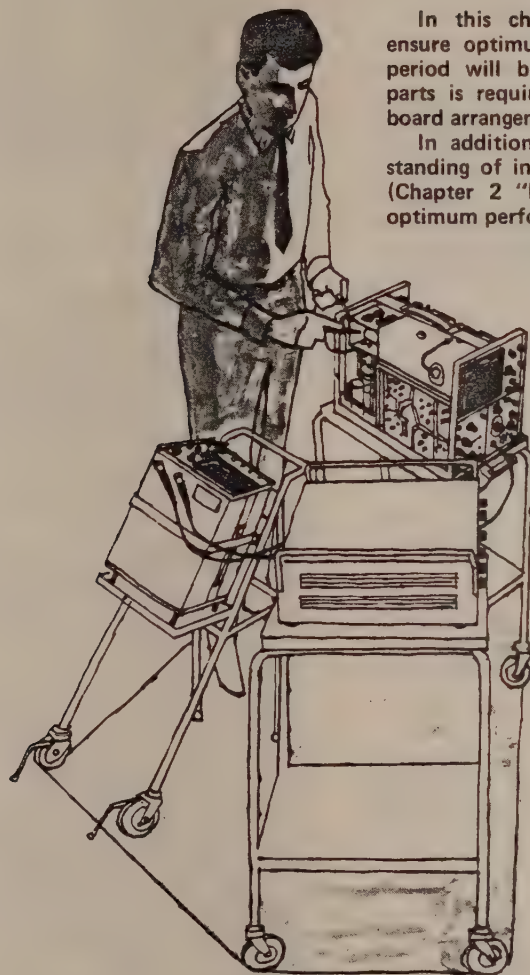
Fig. 4-29 CALIBRATOR



CHAPTER 5 MAINTENANCE

In this chapter, maintenance procedures which will ensure optimum operation of this instrument for a long period will be described. If testing or replacement of parts is required, refer to the circuit and printed circuit board arrangement diagrams.

In addition to proper maintenance, a thorough understanding of instrument performance and proper operation (Chapter 2 "Pre-Start Operation") is essential to ensure optimum performance.



Preventive Maintenance	5-2
Troubleshooting	5-2
Parts Replacement	5-5

▷ Preventive Maintenance

Maintenance procedures listed herein outline periodic tests which insure optimum operating efficiency and indicate preventive maintenance measures when required.

Cleaning

A periodic cleaning is necessary depending on the operating conditions. Dust accumulating in the instrument affects the radiation of heat and may cause overheating and the subsequent failure of parts. Foreign substances on on switch contacts or connectors result in poor contact and on printed circuit boards may cause arcing in damp climates or seasons. Suitable cleaning agents are listed in Table 5-1. Those agents indicated as unsuitable must not be used.

Table 5-1

Suitable Cleaning Agents	Alcohol and Xylene
Unsuitable	Acetone, methyl-ethyl-ketone, ether, lacquer thinner, and chemicals containing ketone series solvents

Cover Ordinary dirt on the cover can be removed by washing the cover with a mild detergent. When grease or oil is present, use a soft cloth and one of the preferred cleaning agents listed in Table 5-1.

Front Panel and Knobs Clean the front panel and knobs with a cotton swab moistened with alcohol. A mild detergent is also available but any residue must be wiped off after use.

Dirt in Instrument The best way to remove dirt or dust inside the instrument is to blow it out with air under pressure. Use of a soft brush in conjunction with the air will aid in the cleaning.

Dirt on CRT Surface If the CRT polarized filter is left off for a long time, the face of the CRT may become dirty. Dust or fingerprints can be removed by wiping the surface with a soft cloth. Stains or sticking dirt can be removed with alcohol or detergent.

Mesh Filter Remove dust with a soft brush or smooth soft cloth such as a nylon stocking. Grease or sticking dirt should be removed with a mild detergent and warm water. After cleaning, rinse the filter in water and dry it thoroughly.

When the Instrument is to be Left Idle

When the instrument is not going to be used for a certain

period, disconnect the probe and adaptor from the panel and cover the instrument with the protective dust cover. Store the accessories in the accessory box and place the instrument in a dry place.

Visual Inspection

A simple visual check of the inside of the instrument will sometimes reveal various defects, such as charred resistors, defective contacts, or broken circuit boards. Immediate repair of these defects will prevent more serious troubles.

▷ Troubleshooting

A thorough understanding of the overall system and circuit operation of this instrument will prove to be a valuable aid in troubleshooting. For this purpose, refer to Chapter 4 "Circuit Description"

Troubleshooting References

Circuit Diagrams The circuit diagrams are classified in accordance with the blocks shown in Fig. 4-1. "Basic Block Diagram". Circuits enclosed by dotted lines in the block diagram are on printed circuit boards.

The location of contacts and wafers of each rotary switch are also indicated. Contact positions on the side of a wafer closest to the front panel are denoted as A-F, and those on the rear side of the front wafer are A-R. Subsequent wafers are indicated as B-F and B-R. Concentric shaft switches are described as aA-F, aA-R, ... (switch closest to front panel and driven by the outer shaft) and bA-F, bA-R, ... (rear switch, driven by the inner shaft).

Voltages and waveforms measured during normal operating conditions are indicated on the diagram. Since these voltages and waveforms will vary depending upon the position of relevant controls; these points should be measured with the controls set as stated.

Location of Circuit Boards The circuit arrangement diagrams in the last section of this manual show the location of circuit boards, and will help in checking these circuits.

Wiring Color Code Wires are color coded according to their function. Two-colored wires are for the power supply circuits, and solid color wires are used for the general circuit wiring. The color code of wires is shown in Tables 5-2 and 5-3. Table 5-3 shows a typical use of wires, however, some wires in this instrument may deviate from the code. Shielded wires are not included in these codes.

Resistor and Capacitor Color Code The resistors and capacitors used in the circuit are color coded as shown in Fig. 5-1.

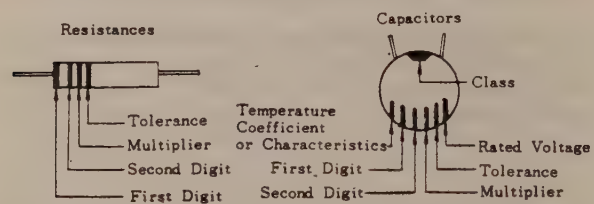
Table 5-2 Color Code of Power Supply Wires (Two-Colored)

Low Voltage Source	Base Color	Stripe Color
-12 V	White	Black
-30 V	Purple	—
-40 V	White	Green
+12 V	White	Red
+27 V	White	Blue
+50 V	White	Yellow
+105 V	White	Orange
+125 V	White	Brown
+235 V	White	Gray

Table 5-3 Color Code of General Wiring (Solid Color)

Circuit	Color
Collector or drain wires	Red
Base or gate wires	Yellow
Emitter or source wires	Blue
Positive voltage wires	Brown
Negative voltage wires	Purple or gray
Other (signal line, etc.)	White
Ground wires	Black

Fig. 5-1 Resistor and Capacitor Color Code



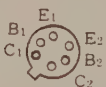
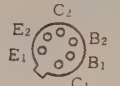
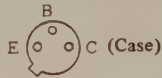
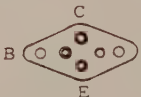
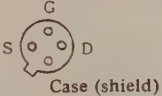
Color	Resistance or capacitance value		Tolerance for resistance (%)	Tolerance for capacity (%)		Rated voltage (Capacitor)
	1st and 2nd significant digits	Multiplier		10 pF or more	10 pF or less	
Black	0	1	—	±20.0	±2.0	—
Brown	1	10	±1	1.0	—	—
Red	2	10 ²	±2	±2.0	—	250 V
Orange	3	10 ³	—	±2.5	—	300 V
Yellow	4	10 ⁴	—	—	—	—
Green	5	10 ⁵	—	±5.0	±0.5	500 V
Blue	6	10 ⁶	—	+100 (-0)	—	—
Purple	7	10 ⁷	—	—	—	—
Gray	8	10 ⁸	—	±10.0	±0.25	—
White	9	10 ⁹	—	—	±1.0	1000 V
Gold	—	10 ⁻¹	±5	—	—	—
Silver	—	10 ⁻²	±10	—	—	—
Not colored	—	—	±20	—	—	—

Identification of Diode and Transistor Elements Element identifying marks for the various diodes and transistors are shown in Tables 5-4 and 5-5.

Table 5-4 Diode Type and Element Identification

Type	Shape and Polarity	
	Shape	Polarity
HFSD-1		
HW 10A HW 20B HW 75A HW 30B HW6.8B SD 15 HW 10B SD 104		
RD 4A 1N746A RD 5A 1S992 RD 6A RD16A		
1S467		
1S552		
1S953 (Orange) 1S955 (Green)		
1S1458		
1S1992		
5EH-6		
5EH-12		
Tunnel Diode 1S1760 1S1763		
Tunnel Diode 1S1762		

Table 5-5 Transistor Type and Element Identification

Type	Electrodes
BFW30 2SC988 2N4260 2N4597 2N4957	 Case
MD3250	
N501-BFY	
2SD 93 2SD 163 2SC 558 2SC1030B	 C (Case)
2SD 221 2N 5109 2SC 154C	 C (Case)
2SD 224	
2SK12-Y 2SJ 12-Y	 Case (shield)
2N3500 2N3637 2N5179	
2N 4121 2SC650B 2SC857 (H) 2SC857 (K)	
2N4258 2N4275	
2N4360	
2N4416	 Case
2SC989	 E (Case)

Measuring Instruments Required for Troubleshooting

The following instruments are required for troubleshooting.

- (1) Multimeter
 - Input Impedance: 10 megohms
 - Voltage Range: Normal range 0 – 300 V, should be capable of measuring 2 kV.
 - Resistance Range: 0 – 20 megohms
- (2) Transistor Curve Tracer
IWATSU Transistor Curve Tracer TT-502 or TT-505
- (3) Synchroscope for Test
 - Frequency Bandwidth: DC – 50 MHz
 - Sensitivity: 5 mV/cm

Prior to Troubleshooting

First, it should be determined whether the instrument is actually defective, or if external conditions are responsible for the trouble indications. For example, when the power source voltage exceeds the allowable operating range, or external noise is induced in the test set-up, the display will become irregular.

When the display, at a certain sweep rate is somewhat irregular and it is difficult to determine whether the instrument is defective, it is advisable to observe another type of signal and see if the same irregularity occurs.

Troubleshooting Procedure and Sequence

The following procedures and sequence of troubleshooting will help to save time.

- (1) Before removing the covers from the instrument, verify all control functions described in Chapter 2, "Operating Procedures." This should aid in isolating the defective portion to a particular circuit such as the low voltage power supply, CH 1 preamplifier, CH 2 preamplifier, trigger generator and so on. (Refer to the following section "Isolation of Defective Circuits According to Trouble Symptoms.")
- (2) Next, remove the cover on the side of the instrument which contains the suspicious circuit, and visually check components, wires, and the printed board for irregularities such as charred wires or resistors, defective contacts or broken wires. Various causes of trouble may be detected by a thorough visual inspection.
- (3) Check the low and high voltage supplies. (Refer to Chapter 6 "Low and High Voltage Supplies".) Trouble in the low voltage power supply has considerable influence on other circuits. Abnormal voltage from power supplies must be corrected.
- (4) Next, use a VOM (or VTVM) or test synchroscope to check the operation of the suspicious circuit, referring to the circuit diagrams in the last section, and localize the defective circuit.
- (5) Check the characteristics of suspicious active elements (transistors or diodes) and passive parts (resistors or capacitors, etc.). Replace any defective part (s). Two or more parts may be defective.

Troubleshooting with Particular Symptoms

Since it is impossible to forecast all possible troubles in this synchroscope, only typical troubles and troubleshooting hints will be described. Follow the procedures described in items (3) to (5) above to isolate defective parts.

No Spot (electron beam) The CRT circuit, Z axis amplifier, vertical or horizontal amplifier is responsible for this trouble. Although it is a rare case, two of these circuits may cause trouble at the same time.

When the MODE switch is changed to CH 1 (or CH 2) and the spot is observed on CH 1, but not CH 2, the CH 2 preamplifier is probably defective. If the spot is not present in either channel, check that the vertical and horizontal deflection voltages are balanced at a given position of the POSITION control. When the voltages are balanced, but the spot is still not present, the CRT circuit or Z axis amplifier is most likely defective. A check of the CRT output voltage circuit or the Z axis amplifier will point to which circuit is defective.

Spot is present, but no sweep Set the HORIZ DISPLAY switch to the CH 1 VERT CH 2 HORIZ position and turn the POSITION (horizontal) control clockwise or counter-clockwise.

If the spot moves horizontally the full width of the graticule with rotation of this control and a normal horizontal amplitude is obtained in accordance with the operation described in Chapter 2 "XY Scope Operation", the horizontal amplifier is normal, and the trouble lies in the sweep generator.

Sweep Present but not triggered When the display can not be triggered by either the internal or external trigger, the trigger generator is defective. If the display is triggered only by an external trigger signal (or rated amplitude), the trigger amplifier is defective.

Dual trace inoperative When only the ALT mode is inoperative, the circuits between the A or B alternate pulse output and the alternate amplifier may be the cause of the trouble. In very rare cases, the switching circuit may be defective. When both the ALT and CHOP modes are inoperative, the switching circuit is probably defective.

Horizontal sweep is not linear If the sweep time in the right and left sides of the display area is not equal, and the display linearity varies with rotation of the POSITION knob, the horizontal amplifier is probably defective, and if the linearity does not vary with the POSITION control, the sweep generator is the most likely cause.

► Parts Replacement

The procedure for removing the panel covers from the plug-in unit in order to perform visual checking of circuits or replacement of defective components will be described.

Removal of Panel Covers

The side panels can be removed by turning the two locks on each panel in the direction marked OPEN. Remove the four screws to remove the rear panel. The bottom cover can be removed by removing the four screws (locked by nuts) located below the side panels.

Removal of the Vert. and the Horiz. Plug-in Units

Remove the two screws (refer to Chapter 6, Fig. 6-10) which are found in the front bottom of the Plug-in Unit and one nut (refer to Chapter 6, Fig. 6-5 and 6-9) which is found in the rear of the Plug-in Unit, and push the unit forward.

Replacement of Semiconductor Elements

Suitable transistors or diodes must be used for replacement. Specially selected transistors are employed in major circuits of this instrument in order to ensure the characteristics described in Chapter 1. (These selected transistors are shown in Table 5-6.)

The semiconductors are sensitive to heat. When the transistor leads are soldered, use heat sinks to prevent the conduction of heat to the actual internal elements. Replace parts as quickly as possible as heat may cause the printed circuits to separate from the laminate.

Table 5-6 Specially Selected Transistors and Diodes

Circuit	Circuit No. of Transistors and Diodes
CH 1 PREAMPLIFIER	TR1A · TR2A (2N4416)
CH 2 PREAMPLIFIER	TR1B · TR2B (2N4416) D5B · D6B (1S1992)
VERT MAIN AMPLIFIER	TR903 · TR904 (2SC989) TR905 · TR906 (2N5179) TR907 · TR908 (2N4260)
A SWEEP GENERATOR	TR407 (2SK-12 Y)
B SWEEP GENERATOR	TR706 (2SK-12 Y)

Replacement of Resistors and Capacitors

Specially selected passive elements, (resistors and capacitors), are used for the instrument, therefore defective parts should be replaced with suitable replacements.

Burnt resistors or shorted capacitors may result from short-circuiting or serious deterioration of transistors or diodes. Check the cause of the trouble, and replace any defective active elements as well as passive elements.

Fuse Replacement

The power line fuse is located on the rear panel, and low voltage power supply fuses are collectively mounted on the right (refer to Fig. 6-5) side of the instrument. Details of fuses are shown in Table 5-7.

Table 5-7 Fuses

Circuit Symbol	Fuse Type	Function	Location of Fuse Holder
F1342	3 A Slow-blow	For AC 100 V line operation	Rear Panel
	1.5 A Slow-blow	For AC 200 V line operation	Rear Panel
F1341	0.5 A Quick action	For -40 V line	Right rear inside
F1401	0.5 A Quick action	For +27 V line	Right rear inside
F1381	0.5 A Quick action	For +50 V line	Right rear inside
F1361	0.25 A Quick action	For +125 V line	Right rear inside
F1201	1 A Quick action	For CRT circuit	Center of upper right

Removal of Circuit Boards

The printed circuit boards can be removed by disconnecting the wires to the board and removing the mounting screws.

The external connections to the board must be properly soldered to the board after replacement in order to avoid damage to transistors and/or resistors.

CRT Replacement

Disconnect the power supply prior to replacement of the CRT because dangerous high voltages are used on the CRT anode and discharge the high voltage which is stored in the high voltage circuit capacitors.

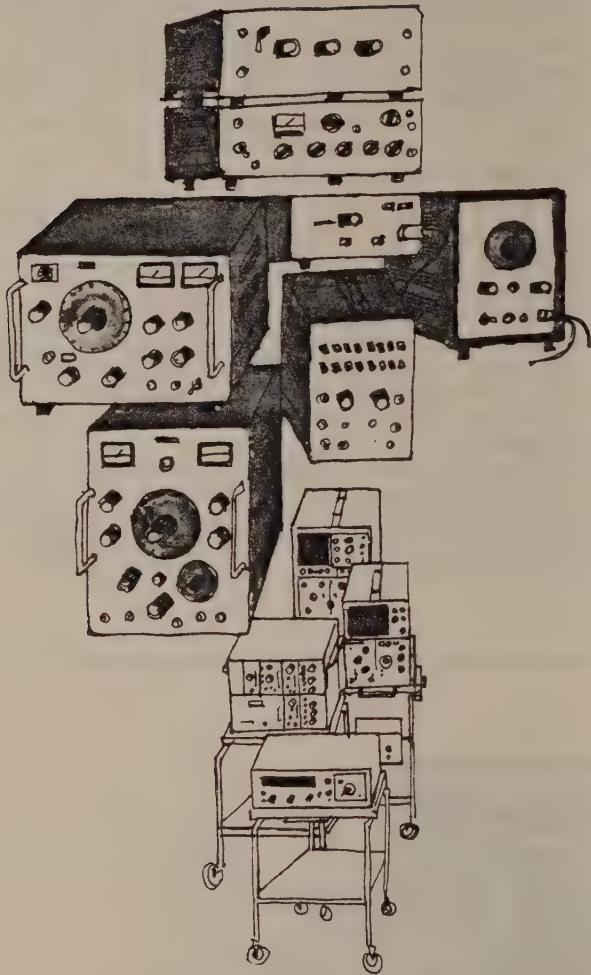
Handle the CRT with extreme care as excessive force or shock may cause it to break or crack. If the deflection plate pins or electrode pins are bent, it may cause the glass sealant around the pins to crack.

Remove the CRT in the following sequence.

- (1) Remove both side panels and the rear panel. Pull out the vertical and horizontal Plug-in Units.
 - (2) Pull out the CRT Socket.
 - (3) Unsolder the wire leads from the rotation and other coils of the CRT.
 - (4) Remove the connectors from the deflection plate pins on the neck of CRT and the anode cap on the right front side of the CRT.
 - (5) Remove the four screws which secure the bezel to the front panel, and remove the bezel and filter.
 - (6) Loosen the two illumination plate screws (on which the scale illumination lamp socket is mounted).
 - (7) Remove the felt-backed metal plate which holds the CRT in place by loosening the two screws which hold the plate.
 - (8) Then, pull the CRT out the front of the instrument.
- Reinstall the CRT in the reverse sequence described above, paying especial attention to the side-pin which must be attached in place.

Calibration is required if the CRT is replaced. (Refer to each item of "Chapter 6, High Voltage, Intensity, CRT Circuit and TERMINATION ADJ).

CHAPTER 6 CALIBRATION



Like all measuring instruments this synchroscope must be calibrated after a certain amount of use. The extent of the calibration, whether overall or partial, differs with the operating condition of the instrument, however, the functions which require calibration can be easily determined by checking the accuracy of the vertical deflection sensitivity, attenuator (VOLTS/CM) phase, sweep time and other functions with the internal CALIBRATOR or accurate external instruments.

In some cases, recalibration may be required when parts are replaced. It should be noted that partial calibration may influence other circuits. For example, the power supply influences almost all circuits, and the high voltage power supply varies the vertical and horizontal deflection sensitivity.

The following calibration procedures include some items which require accurate test instruments and particular skill. If proper test instruments are not available, these items must be calibrated by factory technicians. In such cases, contact IWATSU's service section or your nearest representative.

Low-Voltage Power Supply	6- 2
High-Voltage Power Supply	6- 2
Intensity	6- 2
CRT Circuits	6- 4
VOLTS/CM (attenuator) Phase (CH 1, CH 2)	6- 5
TERMINATION ADJ	6- 7
Main Amplifier GAIN	6- 7
Main Amplifier DC BAL	6- 7
NEON CENTER, NEON ADJ	6- 7
POSITION CENTER (CH 1, CH 2)	6- 7
Preamplifier GAIN, 5 mV GAIN (CH 1, CH 2)	6- 8
STEP ATTEN BAL (CH 1, CH 2)	6- 8
Preamplifier DC BAL (CH 1, CH 2)	6- 8
INVERT BALANCE (CH 2)	6- 8
TRIG DC BAL	6- 8
TRIG DC LEVEL	6- 9
TRIG GAIN	6- 9
CH 2 OUT DC LEVEL	6- 9
Cascade Connection Sensitivity	6-10
A Trigger LEVEL CENTER	6-10
A TRIG SENSE	6-10
A Trigger TRIG STABILITY	6-10
A Sweep T.D. BIAS	6-10
A Sweep FET BIAS	6-10
A Sweep STABILITY	6-10
Horiz. Amplifier +105 V and -30 V Adjustment	6-10
A Sweep SWEEP CAL, Horiz. Amplifier NORM GAIN and x10 MAG GAIN	6-10
Horiz. Amplifier GAIN and A Sweep Time	6-11
A Sweep Length	6-11
Horiz. Amplifier phase	6-11
B Trigger LEVEL CENTER	6-11
B TRIG SENSE	6-11
B Trigger TRIG STABILITY	6-12
B Sweep T.D. Bias	6-12
B Sweep FET Bias	6-12
B Sweep STABILITY	6-12
B Sweep Time	6-12
B Sweep Length	6-13
DELAY TIME MULTI	6-13
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CAL ADJ of Calibrator Voltage	6-13
Calibrator Output Frequency	6-13
Vert. Deflection System Square Wave and Frequency Characteristics (CH 1, CH 2)	6-14
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Low-Voltage Power Supply

The power supplies must be checked prior to calibration of other circuits. The low voltage power is supplied to all circuits, therefore, the output voltages of power supplies must be adjusted by using an accurate DC voltmeter (class 0.5 or higher).

Regulated power supplies are provided as shown in Table 6-1. Power supply test point locations are shown in Figs. 6-1 and 6-2. Measure the voltage between the test point and the chassis and adjust the output voltage in the sequence shown in Table 6-1. For adjustment of the +105 V and -30 V supplies, refer to "Horizontal Amplifier +105 V and -30 V Adjustment" which will be described later. Variable resistors for each adjustment are also indicated in Fig. 6-1.

High Voltage Power Supply

Variation of the high voltage will cause variation in the deflection sensitivity of both the vertical and horizontal axes of the CRT. An excessive voltage variation will vary the focus of CRT. The two voltages in Table 6-2 should be adjusted or confirmed.

First measure the cathode voltage across the test point (shown in Fig. 6-1) and the chassis, and adjust the voltage

to -2450 V with H.V. ADJ R1201 (refer to Fig. 6-2). Then, confirm that the anode voltage shown in the table is correct, by measuring the voltage between the anode electrode pin and the chassis. A calibrated high input impedance VTVM must be used for the measurements. Exercise caution when measuring high voltages to avoid electrical shock, also refer to the relevant items in Chapter 5 "Replacement of the CRT".

Intensity

Low intensity will hamper observation of the display, and excessive intensity will burn the phosphor coating of the CRT. Optimum intensity is obtained when the intensity circuit controls are set at the following positions.

Turn the A SWEEP MODE to the NORM position to stop the sweep, and the INTENSITY controls fully counterclockwise. Adjust the INTEN ADJ R1211 (refer to Fig. 6-2) clockwise until the spot appears then turn the adjustment slightly counterclockwise until the spot just disappears.

Turn the A SWEEP MODE switch to the AUTO position to actuate the sweep. Gradually turn the Z AMPL. LEVEL control R1106 (Fig. 6-1) from the extreme right position (fully clockwise) counterclockwise until trace intensity just starts to increase.

Fig. 6-1 Rear View

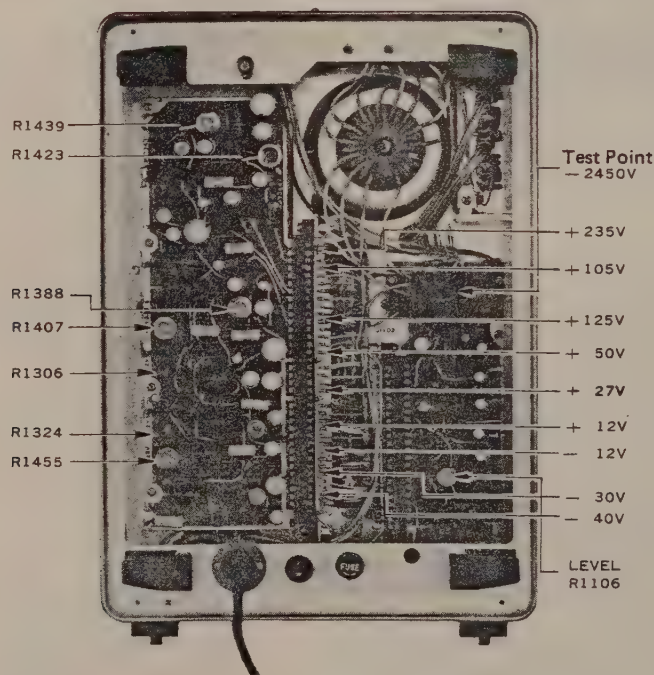


Table 6-1

Power Supply	Type	Color Code of Wiring	Tolerance	Ripple Voltage	Measuring Condition	Sequence Adjustment	Variable Resistor for Adjustment
-12 V	Regulated	White/Black		500 μ V or less	Calibrate at line voltage of 100 V	1	R1324
*-30 V	"	Purple	-26 V - -34 V	1 mV or less	"	5	R1455
-40 V	"	White/Green	-38 V - -42 V	1 mV or less	"	Automatically calibrated when procedures 1 to 3 are completed.	
+12 V	"	White/Red		500 μ V or less	"	2	R1306
+27 V	"	White/Blue		2 mV or less	Calibrate at line voltage of 100 V	4	R1407
+50 V	"	White/Yellow		5 mV or less	"	3	R1388
*+105 V	"	White/Orange	+100 V - +115 V	2 mV or less	"	6	R1439
+125 V	"	White/Brown	+122 V - +128 V	5 mV or less	"	Automatically calibrated when procedures 1 to 3 are completed.	
+235 V	"	White/Gray		1 mV or less	"	7	R1423

* Refer to item "Horiz. Amp. +105 V and -30 V Adjustment".

Fig. 6-2 Top View

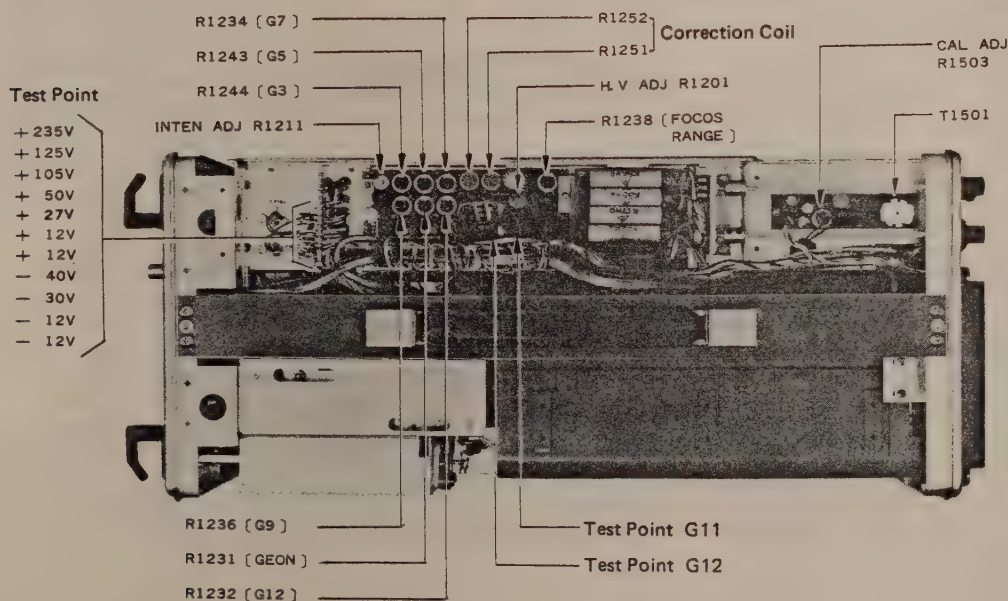


Table 6-2

High-voltage Power Supply	Wire Color	Normal Voltage
CRT Cathode Voltage	White/Green	-2450 V $\pm$ 10 %
CRT Anode Voltage	Red	+13 kV - +14 kV

CRT Circuit

In addition to the high voltage and intensity adjustments, the following calibration procedures are required for the CRT circuit.

(1) Set the BANDWIDTH switch to the 50 MHz range.
 (2) Feed a square-wave signal of about 100 kHz to the INPUT and adjust the input level so that the vertical deflection output will become 8 Vp-p when the output voltage is measured with another calibrated synchroscope. Adjust the sweep time until four or five cycles of the square-wave signal are sidplayed. Adjust the TRACE ROTATION control (on the right side panel) to align the horizontal sweep axis with the graticule.

(3) Set the following controls to their mid-position.
 INTENSITY knob (front panel)
 R1231 (GEOM) (refer to Fig. 6-2)
 R1232 (G12 pin) (refer to Fig. 6-2)
 R1234 (G7 pin) (refer to Fig. 6-2)
 R1238 (FOCUS RANGE) (refer to Fig. 6-2)

(4) Adjust R1236 (G9) for a display amplitude of 4 cm. (See Fig. 6-2.)

(5) Adjust the FOCUS A and FOCUS B controls (on the front panel) for the sharpest trace. FOCUS A affects the vertical trace and FOCUS B affects the horizontal trace.

(6) Advance the VOLTS/CM switch one step to overdrive the vertical deflection system, and accurately adjust the sweep time to align each vertical trace on the vertical graticule scale. Correct the pattern distortion until the pattern shown as "GOOD" in Fig. 6-3 is obtained, by turning the GEOM control R1231. Check that the dc voltage at pin G12 of the CRT (at the test point in Fig. 6-2) is approx. 10 V lower than the test point voltage for pin G11 (see Fig. 6-2). If it is not, adjust R1232 (G12). If the adjustment of R1232 causes the pattern to distort, repeat the adjustment of the G12 and GEOM R1231 con-

trols. Return the VOLT/CM switch to the position in step 2 overdrive. Should the vertical amplitude in this sequence deviate from 4 cm on the graticule, repeat steps 4 to 6.
 (7) Repeat the adjustment of FOCUS (A) and FOCUS (B) for optimum focus. Adjust R1244 (G3 pin, refer to Fig. 6-2) for optimum sharpness of the horizontal axis. Repeat these adjustments.

(8) Proper focusing is obtain by the adjustment of the FOCUS (A) control if the focus deteriorates when display intensity is changed with the INTENSITY control. If proper focusing is not obtained with the FOCUS (A) control, rotate R1238 (FOCUS RANGE) slightly in either direction, and repeat steps (7) and (8).

(9) Adjust R1234 (G7) to equalize the intensity of the right and left ends of the display.

(10) Short the vertical deflection output, turn R1251 and R1252 (correction coils, refer to Fig. 6-2) fully counterclockwise. Adjust R1243 (G5 pin, refer to Fig. 6-2) so that the horizontal trace is aligned with the graticule scales center horizontal line.

(11) The next step is the alignment of the X and Y axis. Note that variation in earth magnetism may change the alignment. Leaving the vertical amplifier output shorted, readjust the TRACE ROTATION control (right side panel) so that the trace is parallel to the horizontal graticule scale. Adjust R1251 and R1252 (correction coil electrodes) so that the trace coincides with the graticule scale horizontal center line. Set these variable resistors as close to the

Fig. 6-4 Raster

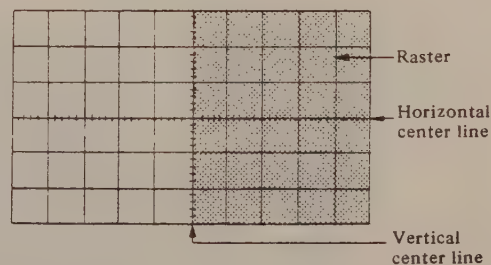
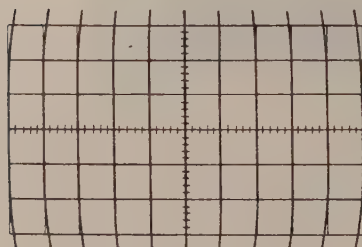
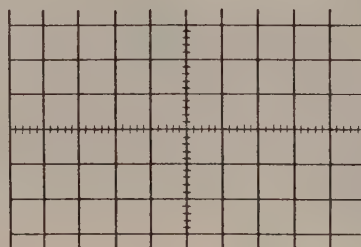


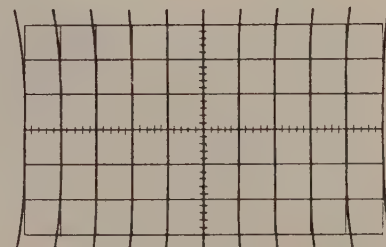
Fig. 6-3 Pattern Distortion Correction



Bad (Barrel)



Good



Bad (Spin)

mid-position as possible. Remove the short from the output of the vertical amplifier. Feed a signal to the INPUT, place the sweep mode in the AUTO position (freerun) to display a raster, and adjust the vertical amplitude to 6 cm centered on the graticule scale. Adjust the HORIZ POSITION control so that the raster correctly starts from the graticule scales vertical center line. (See Fig. 6-4.) Adjust R1251 and R1252 alternately until the start of the raster coincides with the vertical center line (90° to the horizontal center line) and the raster's vertical position is correct.

VOLTS/CM (attenuator) Phase (CH 1 · CH 2)

If the phase characteristics of the VOLTS/CM attenuator are not equal for each range, the frequency response will deteriorate and distortion will occur in the displayed waveform.

The phase compensation trimmers can be adjusted from the front of the instrument as shown in Fig. 6-6. The index plate must be removed from the front panel, but the VOLTS/CM switch knob need not be removed. The index plate can be removed simply by loosening the mounting screws. (When the index plate is re-installed) align the tabs of the index plate with the corresponding front-panel holes.

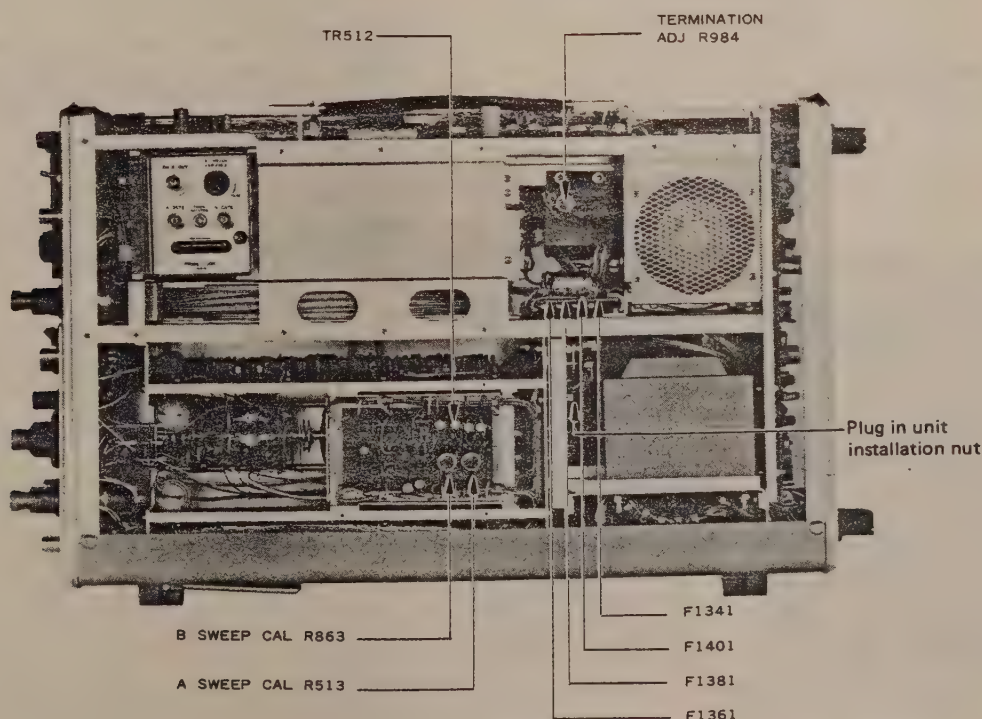
After removing the index plate from the front panel, connect the INPUT terminal to the CAL OUT terminal through the attached coaxial cable (BB-500). Turn the

VARIABLE control fully clockwise, set the VOLTS/CM switch to the 10 mV position and the CALIBRATOR VOLTS to the 50 mV ranges. The vertical display amplitude should be 5 cm.

Adjust trimmers C36A/B (refer to Fig. 6-9, C36A for CH 1 and C36B for CH 2) to compensate the leading edge of the display (part A in Fig. 6-7) by obtaining the proper condition as shown in Fig. 6-7. Disregard part B in this adjustment. Change the VOLTS/CM switch to the 20 mV position, and set the CALIBRATOR VOLTS control to the 0.1 V position. Adjust trimmers C4A/B for this range.

Referring to Table 6-3, adjust the attenuator phase at each position of the VOLTS/CM switch. Replace the coaxial cable BB-500 with the probe (1022), set the VOLTS/CM switch to the 20 mV position and set the CAL VOLTS to the 1 V position. The display amplitude should be 5 cm. Adjust the probe phase compensator (Fig. 3-6) for the optimum compensation shown in Fig. 6-7. Note that the part A in the figure does not apply in this adjustment. Adjust C2A/B to cause maximum over compensation (the capacitance of C2A/B will be at a minimum). Readjust the probe phase compensator for the optimum compensation as shown in Fig. 6-7. Alternately connect the probe to CH 1 and CH 2 to check the displayed waveforms. One of the two channels may be out-of-phase. Referring to Fig. 6-7, determine if the compensation for the out-of-phase channel is either excessive or insufficient. Correct the phase error as described below.

Fig. 6-5 Right Side View



Correction of Overcompensation

Adjust trimmer C2 (A for CH 1 and B for CH 2) in the opposite channel for adequate compensation, and re-adjust C2 for the other channel.

Correction of Insufficient Compensation

Leaving the probe connected to the first channel, adjust the probe phase compensator. After adequate compensation is obtained, connect the probe to the other channel, and adjust C2 for that channel for adequate compensation.

Check that both the attenuator phase and probe phase

are correct in the two channels. Through the these adjustments, the CH 1 and CH 2 input capacitance are adjusted for minimum equal values at the 20 mV range.

Turn the VOLTS/CM switch to the 10 mV position, and set the CALIBRATOR VOLTS control to the 0.5 V range. The vertical amplitude of the display should be 5 cm. Adjust capacitors C38A/B for the optimum condition shown in Fig. 6-7. Part A in the figure does not apply in this adjustment. Change the VOLTS/CM switch to the 50 mV position and set the CALIBRATOR VOLTS control to the 2 V range. Adjust capacitors C6A/B for the proper waveform. Repeat the same adjustment for each attenuator position in accordance with the procedure in Table 6-4.

Table 6-3

VOLTS/CM Range	Sequence	Calibration Trimmer for Part A
5 mV		
10 mV	1	C36A/B
20 mV	2	C 4A/B (X 2)
50 mV	3	C 7A/B (X 5)
.1	4	C12A/B (X 10)
.2	5	C15A/B (X 20)
.5	6	C19A/B (X 50)
1	7	C23A/B (X100)
2	8	C27A/B (X200)
5	9	C31A/B (X500)

Table 6-4

VOLTS/CM Range	Sequence	Calibration Trimmer for Part B
5 mV		
20 mV	1	C2A/B and probe calibration trimmer
10 mV	2	C38A/B
50 mV	3	C 6A/B (X 5)
.1	4	C10A/B (X 10)
.2	5	C14A/B (X 20)
.5	6	C18A/B (X 50)
1	7	C22A/B (X100)
2	8	C26A/B (X200)
5	9	C30A/B (X500)

Fig. 6-6-1

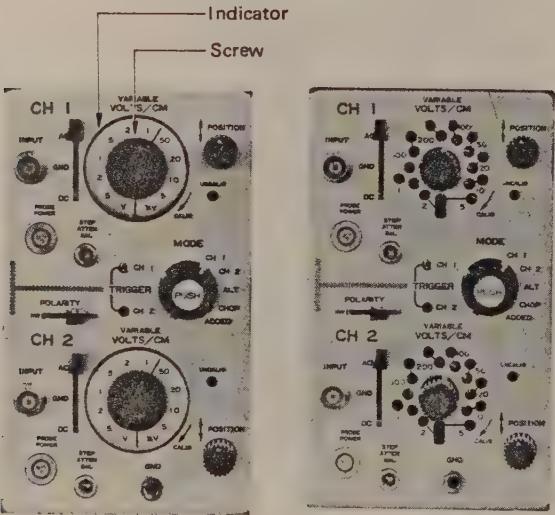
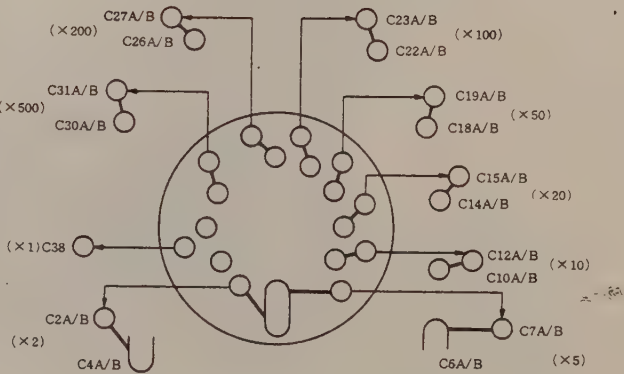


Fig. 6-6-2



TERMINATION ADJ

Improper termination of the deflection system will result in waveform distortion and improper amplification. The required characteristics of the test instrument for this calibration are as follows.

Square-wave Generator	
Rise Time:	300 psec or less
Output Voltage:	40 mV or more
Output Waveform:	Must have low distortion

Set the controls as shown below.

BAND WIDTH	FULL
VOLTS/CM	10 mV
VARIABLE	CALIB
HORIZ DISPLAY	A
A TIME/CM	10 nSEC
VARIABLE	CALIB

Connect the square-wave generator output to the INPUT terminal. Use a 50-ohm high-frequency termination resistor (for example BB50M1) to terminate the cable and to provide correct matching. Adjust the generator output to set the display vertical amplitude to 4 cm on the graticule. If the CRT vertical deflection system is not terminated correctly, a step-like distortion will occur at a point approximately 5 nsec from the leading edge of the displayed waveform, as shown in Fig. 6-8. Minimize the step-like distortion by adjustment of the TERMINATION ADJ R984 (Fig. 6-5).

Main Amplifier Gain

Connect the CAL OUT terminal to the INPUT, adjust the sweep time so that several square-wave cycles are displayed on the graticule, and set the BANDWIDTH switch to the FULL position. While measuring the input voltage across the bases of TR901-TR902 (test points M and N, refer to Fig. 6-9) with a correctly calibrated synchroscope, adjust the VOLTS/CM switch and VARIABLE control so that the input signal amplitude will be 280 mV p-p. Adjust the GAIN control R941 (Fig. 6-9) to set the display amplitude to 4 cm.

Main Amplifier DC BAL

Short the bases of TR901 and TR902 (test points M and N). Adjust DC BAL control R910 (Fig. 6-9) so the trace coincides with the graticule scale horizontal center line.

NEON CENTER, NEON ADJ

Adjust the NEON CENTER control R952 (Fig. 6-9) so that the spot or trace neon-tube indicator (top or bottom) will light when the spot or trace is an equal distance (above or below) from the center line. Adjust the indicator sensitivity control, NEON ADJ R953 (Fig. 6-9) so that the lamp will light when the spot or trace is 2 cm above or below the horizontal center line. Repeat the adjustment of these two controls.

POSITION CENTER (CH 1, CH 2)

The POSITION CENTER adjustment controls the variable range of the POSITION control (vertical) so that the trace will be placed on the graticule scale horizontal center line when the POSITION control is set to mid-position. Adjust the POSITION CENTER control R143A/B (Fig. 6-9) to obtain this condition.

Fig. 6-8

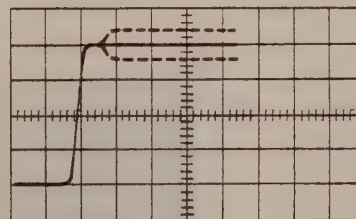
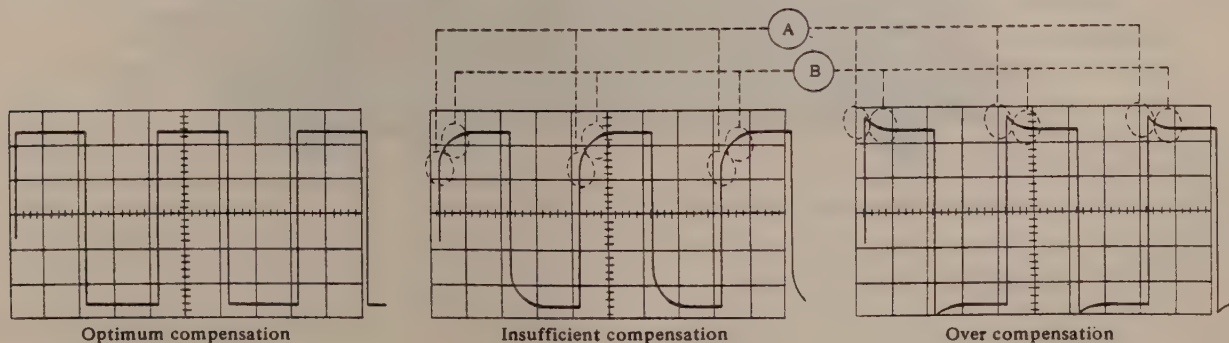


Fig. 6-7 VOLTS/CM Phase Calibration



Preamplifier GAIN, 5 mV GAIN (CH 1, CH 2)

A calibrated signal generator is required for this adjustment, however, the CAL VOLT output of this synchroscope will be sufficient to accurately calibrate the gain to within 2 %. Set the MODE switch to CH 1 or CH 2, VOLTS/CM switch to 10 mV, and the VARIABLE control to the CALIB position. Feed a signal generator output (1 kHz, 50 mV) to the INPUT connector. Adjust the GAIN control R116A/B (refer to Fig. 6-9) so that the display will be 5 cm in amplitude.

Change the VOLTS/CM switch to the 5 mV position and reduce the signal voltage to 20 mV. Adjust the 5 mV GAIN control R86A/B (refer to Fig. 6-9) for a display amplitude of 4 cm.

STEP ATTEN BAL (CH 1, CH 2)

The STEP ATTEN BAL control functions to hold the vertical position of the trace when the VOLTS/CM switch is changed from the 10 mV to the 5 mV position. Adjust the STEP ATTEN BAL control R97A/B (on the front panel) until vertical shift of the trace is eliminated when the VOLTS/CM switch is changed from 10 mV to 5 mV.

Preamplifier DC BAL (CH 1, CH 2)

Adjust the DC BAL control R47A/B (refer to Fig. 6-9) until the trace vertical position does not shift when the VARIABLE control is adjusted.

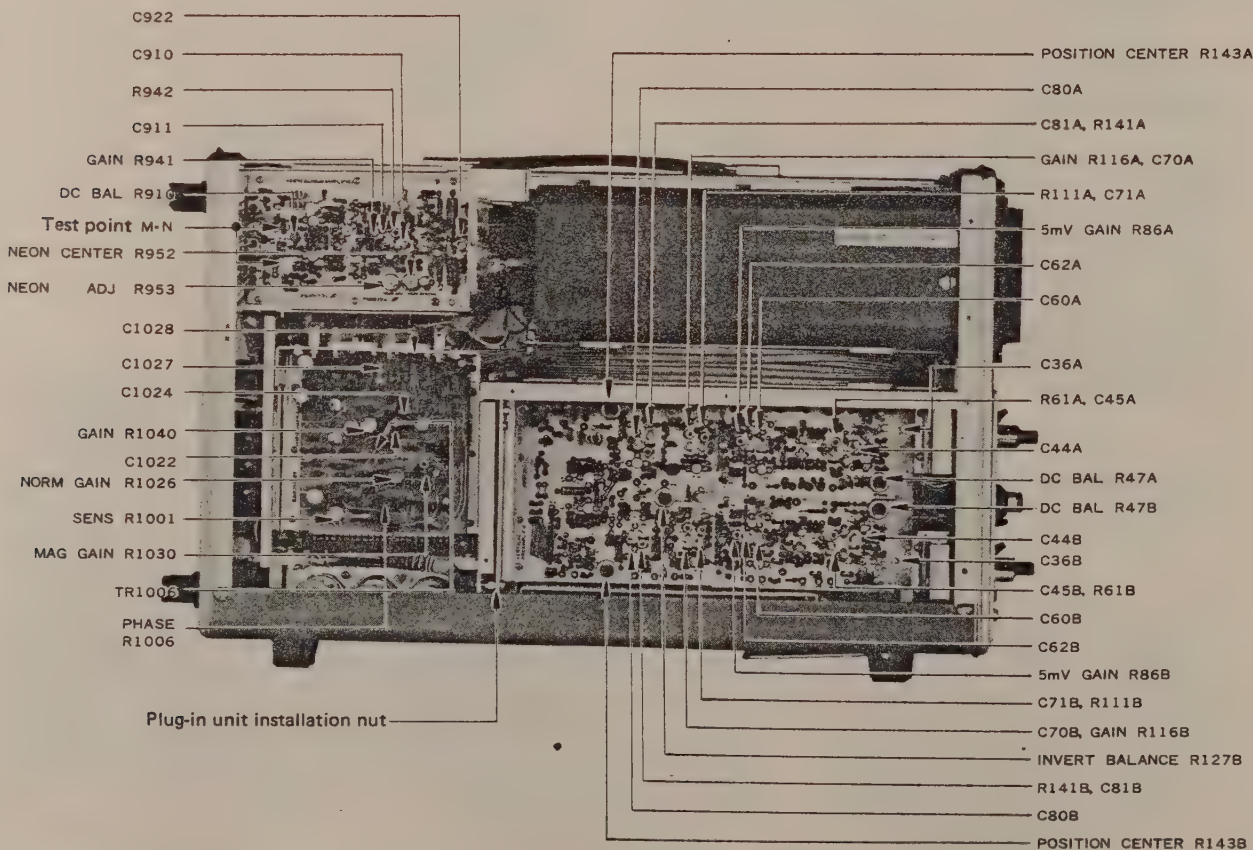
INVERT BALANCE (CH 2)

If the vertical display position shifts when the POLARITY switch is changed from NORM to INV, adjust the INPUT BALANCE control for CH 2. Set the MODE switch to the CH 2 position and adjust the INVERT BALANCE control R127B (refer to Fig. 6-9), so that the traces vertical position does not change when the POLARITY switch is changed from the NORMAL to the INV position.

TRIG DC BAL

The TRIG DC BAL control is used to improve the trigger amplifier linearity. Prior to the adjustment of this control, turn the CH 1 and CH 2 AC-GND-DC switches to the GND position, and balance the dc voltage distribution in these

Fig. 6-9 Left Side View



channels by using the DC BAL control R47A/B in each respective channel. Turn the MODE switch to the CH 1 position, and adjust the TRIG DC BAL control R208A (refer to Fig. 6-10) so that the collector potentials of TR280A and TR281A are equal. Change the MODE switch to the CH 2 position, and adjust R208B (in Fig. 6-10) to equalize the collector potentials of TR201B and TR202B.

TRIG DC LEVEL

If the output level of the trigger amplifier is not correctly adjusted to zero volts, the trigger level zero point in the dc coupled trigger mode varies with the rotation of the LEVEL control. The TRIG DC LEVEL must be calibrated after the TRIG DC BAL adjustment is completed.

Adjust the A TRIGGER DC LEVEL control R287 (Fig. 6-10) to set the trigger amplifier A trigger output, i.e. the collector potential of TR280, to zero volts.

TRIG GAIN

The next step is calibration of the trigger amplifier gain.

Set the VOLTS/CM switch to the 10 mV position and the VARIABLE control to the CALIB position. Set the output level of a sine-wave signal generator to 40 mV p-p at 1 kHz, and connect the signal to the INPUT connector. Measure the output voltage of TR280, i.e. the voltage across point V and the chassis by using an other calibrated synchroscope. Adjust TRIG GAIN R264 (Fig. 6-10) to set the output voltage to 1 V p-p.

CH 2 OUT DC LEVEL

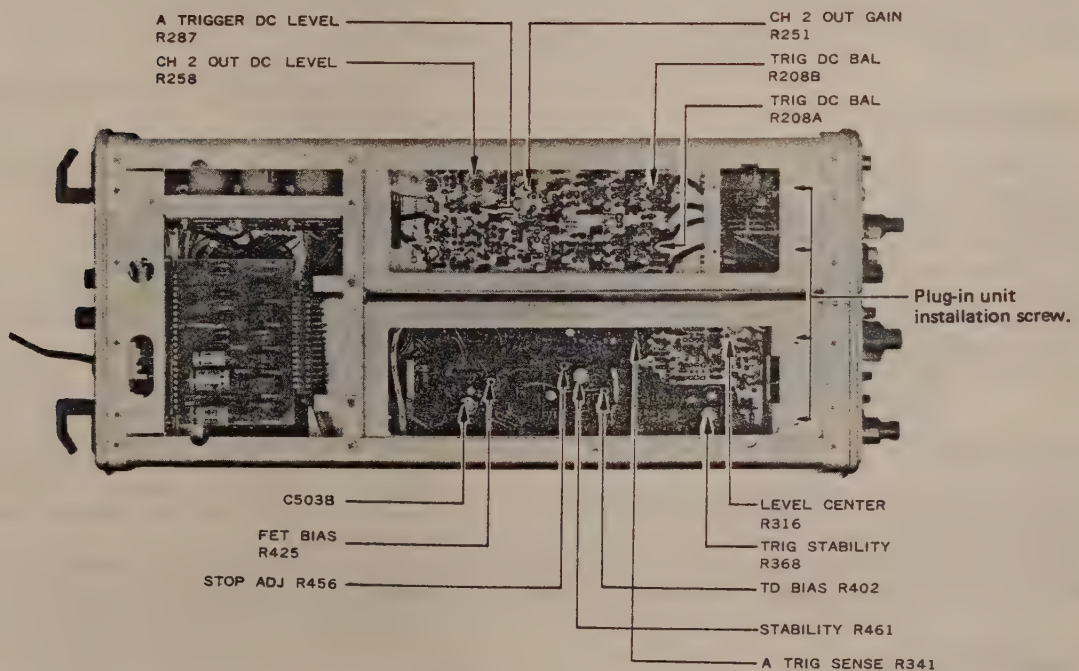
If the CH 2 output level is not zero volts, the vertical position will shift when the amplifiers are connected in cascade. The CH 2 output dc level must be adjusted after calibration of the TRIG DC BAL is complete.

Set the controls as follows.

BAND WIDTH	50 MHz
MODE	CH 1
VOLTS/CM	5 mV
AC-GND-DC	GND
POSITION (CH 1)	Set the trace to the center of the graticule.

Leave the MODE in CH 1 and set the AC-GND-DC switch to DC position and connect a coaxial cable between

Fig. 6-10 Bottom View



the CH 2 OUT and the CH 1 INPUT. If the trace's vertical position shifts during cascade connection of the two amplifiers, correct the shift by using the CH 2 DC LEVEL control R258 (Fig. 6-10).

Cascade Connection Sensitivity

Connect the two amplifiers in cascade referring to Chapter 2 "Cascade Connection Operation". Adjust the CH 2 OUT GAIN control R251 (refer to Fig. 6-10) to set the overall sensitivity to 1 mV/cm.

A Trigger LEVEL CENTER

Set the HORIZ DISPLAY to A, SOURCE (A) to INT and COUPLING (A) to AC. Feed a 1 kHz sine wave to the INPUT connector, set the LEVEL control to mid-position and trigger the display. Adjust the LEVEL CENTER control R316 (refer to Fig. 6-10) so that the display is triggered symmetrically by the displayed waveform at the + and the - slope mode of the SLOPE switch.

A TRIG SENSE

Turn the HORIZ DISPLAY switch to A, SOURCE (A) to EXT and COUPLING (A) to AC. Feed a 1 kHz sine wave, 100 mV p-p, to the vertical INPUT and TRIG INPUT connectors.

Check that A trigger TRIG CENTER R316 operates properly as described above, and adjust the TRIG SENSE R341 (Fig. 6-10) for correct triggering. If the sensitivity is set too high, internal noise may interrupt proper triggering when the SOURCE (A) switch is set to the INT position.

A Trigger TRIG STABILITY

In this circuit, high repetition frequency trigger signals are counted down by an integer in order to ensure stable operation of the following circuit. Push the PULL HF switch in, and feed a 200 MHz sine-wave signal to CH 1 INPUT. Adjust the TRIG STABILITY R368 (Fig. 6-10) so that the trigger circuit will be held immediately before starting self oscillation.

If the triggering sensitivity is set too high, synchronization will be interrupted by internal noise.

A Sweep T.D. BIAS

The tunnel diode bias voltage determines the A sawtooth generator operating point. Adjust the T.D. BIAS control R402 (Fig. 6-10) so that the display will be triggered in a stable manner when a trigger is applied, and the display sweep will stop when the trigger signal is not present.

A Sweep FET BIAS

This variable resistor determines the bias voltage for FET TR407. Set the TIME/CM (A) switch to the 10 nSEC range with no-sweep and adjust the FET BIAS control

R425 to set the collector dc potential of TR406 to zero volts. Location of the adjustment is shown in Fig. 6-10.

A Sweep STABILITY

When the MODE (A) switch is in the SINGLE position, a trigger signal is present, and the trigger circuit is ready for single sweep operation, the input waveform should be displayed only once (single sweep) when the RESET button is depressed.

If a sweep is not obtained, or is swept repeatedly despite the above control settings, the STABILITY control R461 (refer to Fig. 6-10) must be re-adjusted for the proper operating condition. The A sweep stability must be recalibrated whenever the A sweep length is changed.

Horizontal Amplifier +105 V and -30 V Adjustment

Set the HORIZ DISPLAY switch to A, and stop the sweep to display a spot on the CRT. Connect the - lead of a dc voltmeter to the emitter of TR1006 (Fig. 6-9) and the + lead to the chassis. Adjust the POSITION knob until the voltage indication on the voltmeter does not change while pushing and pulling the POSITION FINE knob ($\times 10$ MAG switch on and off).

Connect the dc voltmeter between the collector of TR1014 (Fig. 6-9) and the chassis (chassis negative). Adjust R1439 in the power supply (Fig. 6-1) to set the meter indication (i.e. collector voltage of TR1014) to +35 V. Change the meter connection to the collector of TR1016 (Fig. 6-9) (chassis negative). Adjust R1455 (Fig. 6-1) in the power supply to set the collector voltage to +35 V. Refer to "Power Supply" in this manual.

A Sweep SWEEP CAL, Horiz. Amplifier NORM GAIN and $\times 10$ MAG GAIN

Change the control setting as shown below.

HORIZ DISPLAY	A
A TIME/CM	1 mSEC.
A VARIABLE	CALIB
A SWEEP MODE	NORM

Check that the A sweep is inactivated. Adjust A SWEEP CAL R513 (Fig. 6-5) to set the emitter voltage of TR512 (Fig. 6-5) to chassis to +38 V.

Feed a 1 msec (accuracy 1×10^{-3} or more) time marker signal to the CH 1 INPUT to start triggering. Repeatedly operate the FINE knob (in and out), and adjust NORM GAIN R1026 (Fig. 6-9) and MAG GAIN R1030 (Fig. 6-9) so that the display will be correctly magnified by 10 times when the FINE knob is pulled out. Repeat the adjustment several times, because these controls interact with each other to some extent.

The absolute interval of displayed time marker pulses (should be 1 div. when not magnified) is not of prime importance in this adjustment, but the relative magnification (10 times) must be strictly obtained.

Horizontal Amplifier GAIN and A Sweep Time

These controls must be calibrated after the calibration

of NORM GAIN and x10 MAG GAIN is completed. Leaving the control setting unchanged push in the PULL x10 MAG knob. Adjust the GAIN R1040 (Fig. 6-9) until the 1 msec. time marker pulses are correctly superimposed on vertical graticule lines (1 cm interval). Check the accuracy of the TIME/CM switch by changing the switch position and time marker frequency.

A Sweep Length

Calibrate the A sweep length after the calibration of horizontal amplifier gain and A sweep time is completed.

Adjust the STOP control R456 (Fig. 6-10) to set the sweep length to exactly 11.5 cm.

Horiz. Amplifier Phase

The horizontal amplifier phase is important to facilitate the X-Y scope operation of the synchroscope. Set the controls as shown below.

HORIZ DISPLAY	CH 1 VERT	CH 2 HORIZ
VOLTS/CM	10 mV (CH 1 and CH 2)	
VARIABLE	CALIB (CH 1 and CH 2)	

COUPLING

DC (A sweep and B sweep)

Feed a 2 MHz sine wave signal to CH 1 and CH 2 INPUT connectors.

Adjust the signal generator output to set the display amplitude to 4 cm in vertical and horizontal directions. Adjust PHASE control R1006 (Fig. 6-9) to set the dimension B in Fig. 3-21 (Chapter 3) to 1.5 mm.

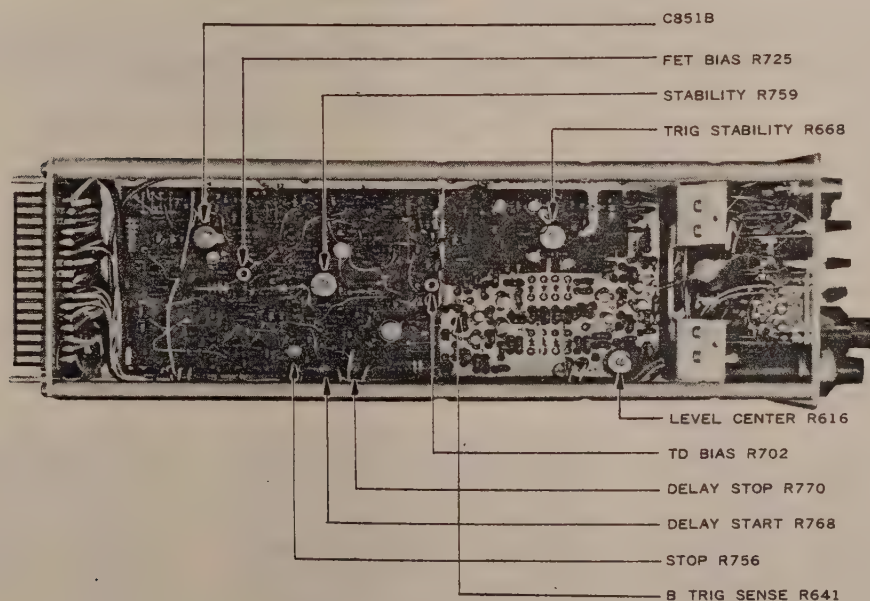
B Trigger LEVEL CENTER

Set the HORIZ DISPLAY to DLY'D (B) and DLY'D (B) MODE to TRIG'D to obtain a triggered delay sweep. Adjust the LEVEL CENTER control R616 (refer to Fig. 6-11) as in the A trigger LEVEL CENTER adjustment.

B TRIG SENSE

Set the HORIZ DISPLAY to DLY'D (B), SOURCE (B) to EXT and COUPLING (B) to AC. Feed a 1 kHz sine wave, 100 mVp-p, to the INPUT and TRIG INPUT connectors. Adjust TRIG SENSE R641 (Fig. 6-11) similar to the calibration of A TRIG SENSE. Check that the B trigger LEVEL CENTER R616 is correctly calibrated, prior to calibrating R641.

Fig. 6-11 Horizontal Axis Plug-in Unit (Top)



B Trigger TRIG STABILITY

Adjust the TRIG STABILITY control R668 (Fig. 6-11) in a similar manner to the A TRIG STABILITY.

B Sweep T.D. BIAS

This adjustment varies the operating point of the B sweep generator. Adjust the T.D. BIAS control R702 (Fig. 6-11), with the DLY'D (B) MODE in the TRIG'D position, so that the display will be triggered firmly when trigger signals are present and the sweep stops when the trigger signal is not present.

B Sweep FET BIAS

A variable resistor used to adjust the bias voltage of FET TR706. Set the TIME/CM (B) switch to the 10 nSEC range with no sweep. Adjust the FET BIAS control R725 (refer to Fig. 6-11) to set the collector dc voltage of TR704 to zero volts.

B Sweep STABILITY

Change the control settings as shown below.

A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
A · B VARIABLE	CALIB
HORIZ DISPLAY	A INTEN BY B
A SWEEP MODE	AUTO
DLY'D (B) MODE	AUTO
DELAY TIME MULTI	5.00

Adjust the STABILITY control R759 (refer to Fig. 6-11) so that the intensified part, approx. 1 cm in length, will start from a point approx. 5 cm from the starting point of the A sweep. Incorrect positioning of the intensified part in this adjustment will cause the B sweep to start earlier or later than the A sweep.

B Sweep Time

Set the controls as shown below.	
HORIZ DISPLAY	DLY'D (B)
B TIME/CM	1 msec
B VARIABLE	CALIB

Feed a 1 msec. time marker signal to the CH 1 INPUT and trigger the sweep. Adjust the B SWEEP CAL R863 (Fig. 6-5) until the time marker signals correctly coincide with the vertical scale of the graticule (1 cm interval). Check the accuracy in each TIME/CM range by changing the time marker frequency and the TIME/CM switch position.

Fig. 6-12 START ADJ Calibration

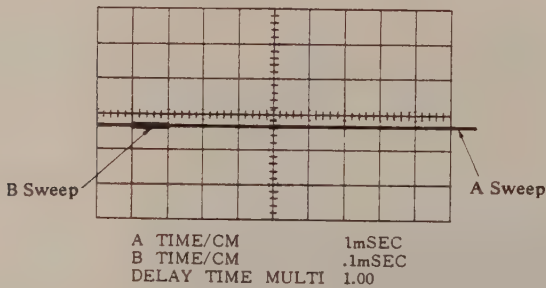


Fig. 6-13 STOP ADJ Calibration

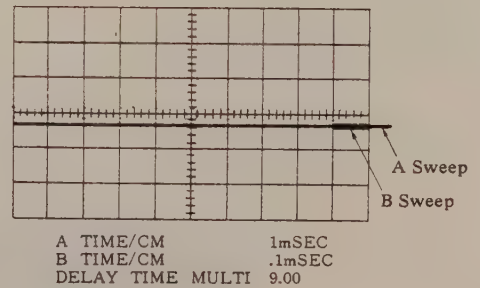
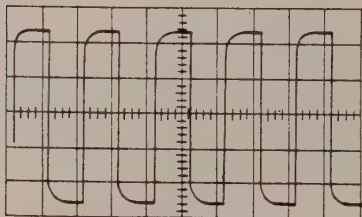
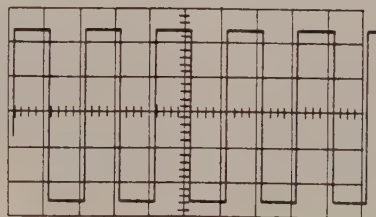


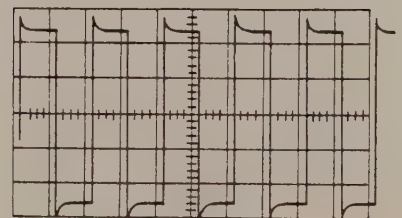
Fig. 6-14 Probe Phase and Output Waveform



Insufficient compensation



Properly



Over compensation

B Sweep Length

Adjust the STOP R756 (Fig. 6-11) until the sweep length becomes identical to the A sweep length.

The trace lengths can be easily compared by changing the HORIZONTAL DISPLAY switch from the A position to the DLY'D (B) position.

DELAY TIME MULTI

This adjustment must be performed after the A and B TIME/CM switch calibrations are completed.

Set the controls as shown below.

A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
A · B VARIABLE	CALIB
HORIZ DISPLAY	A INTEN BY B
A SWEEP MODE	AUTO
DLY'D (B) MODE	AUTO

(1) Adjust the A sweep so it starts exactly at the extreme left vertical graticule scale and set the DELAY TIME MULTI potentiometer to 1.00. Adjust the DELAY START control R768 (Fig. 6-11) so that the B sweep (an intensified portion of the trace, 1 cm in length) will start from the beginning of the second vertical scale from the left end of the graticule (Fig. 6-12).

(2) Change the DELAY TIME MULTI dial to 9.00, and adjust the DELAY STOP control R770 (Fig. 6-11) so that the B sweep starts at the 10th vertical scale of the graticule. Repeat steps (1) and (2) until both conditions are satisfied.

Z Amplifier LEVEL

Refer to "Intensity Calibration" for calibration of the Z axis amplifier LEVEL.

CAL ADJ of Calibrator Voltage

Adjust the CAL ADJ control R1503 (refer to Fig. 6-12) by feeding the calibrator output voltage back to the vertical INPUT after the vertical deflection sensitivity calibration is completed by using an accurate signal generator.

Calibrator Output Frequency

Apply a calibrated 1 kHz signal to the CH 1 INPUT and connect the CAL OUT to the CH 2 INPUT. Rotate the ferrite core of the transformer T1501 (refer to Fig. 6-2) until the 1 : 1 Lissajous' figure on the screen stops.

Fig. 6-15 Probe and Square-wave Generator Connection

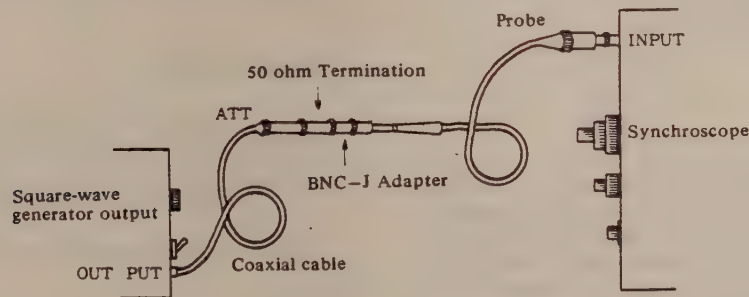
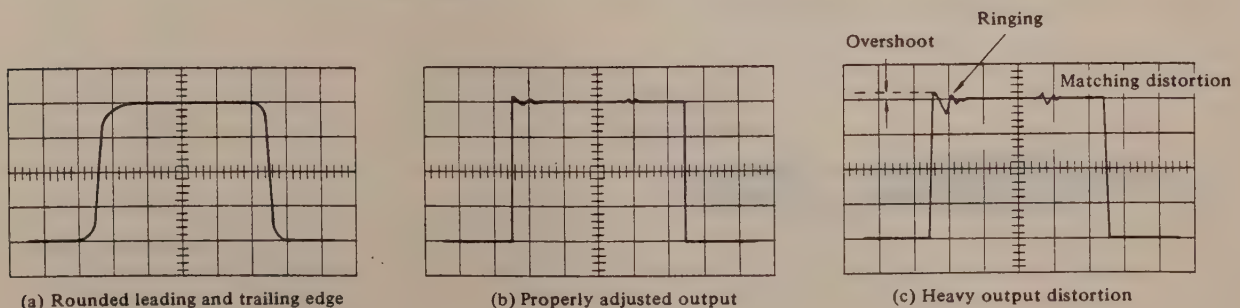


Fig. 6-16 HF Characteristics check of synchroscope Using Square-wave



Vertical Deflection System Squarewave and Frequency Characteristics (CH 1, CH 2)

The test instruments shown below are required for the calibration of the vertical deflection system squarewave and frequency characteristics. If any of these instruments are not available, do not attempt to adjust the response characteristics because an insufficient test set-up will result in erroneous calibration.

Squarewave Generator	
Rise time	300 psec or less
Output voltage	0 to 1 V p-p
Output waveform	must have low distortion
Coaxial Cable	
Characteristic impedance	50 ohms
50 ohm Termination Load	(BB 50M1)
BNC-J Adaptor	(Refer to "Probe Adjustment" to be described later.)
50 ohm Coaxial Attenuator	
	6 dB or more
	(Refer to "Probe Adjustment" to be described later.)
Signal Generator	
Frequency range	10 to 300 MHz or more
Output voltage	100 mV p-p or more

Squarewave Characteristic Calibration Connect the test instruments as follows; squarewave generator output — 50 ohm coaxial cable — 50 ohm coaxial attenuator — 50 ohm termination load — synchroscope INPUT.

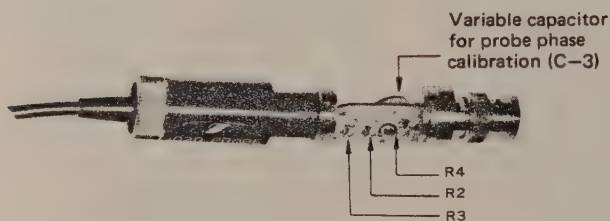
(1) CH 1 Calibration (10 mV range)

Set the controls as shown below.

BAND WIDTH	FULL
MODE	CH 1
VOLTS/CM (CH 1)	10 mV
VARIABLE (CH 1)	CALIB
HORIZ DISPLAY	A

Connect the squarewave generator output to the CH 1 input, adjust the output to deflect the trace 4 cm in vertical amplitude, and position the display at the center of the CRT graticule. Adjust the A TIME/CM control and A VARIABLE control so that a desired part of the display will be adequately enlarged. Adjust the capacitors and resistors (for CH 1 — 10 mV) for an optimum squarewave display. Sharp rise of the squarewave is essential as long as it balances with the amount of overshoot in the displayed waveform.

Fig. 6-17 HF Compensation Circuit in Probe 1022



(2) CH 2 Calibration (10 mV range)

Set the controls as shown below and calibrate CH 2 in a similar manner as CH 1.

BAND WIDTH	FULL
MODE	CH 2
VOLTS/CM (CH 2)	10 mV
VARIABLE (CH 2)	CALIB
CH 2 POLARITY	NORM
HORIZ DISPLAY	A

Connect the input signal to the CH 2 INPUT, and adjust C.R.L for CH 2 10 mV as in Fig. 6-9.

(3) Equalize the CH 1 and CH 2 squarewave characteristics. (Channel frequency characteristics must be taken into consideration for this adjustment.)

(4) CH 1 and CH 2 Calibration at 5 mV

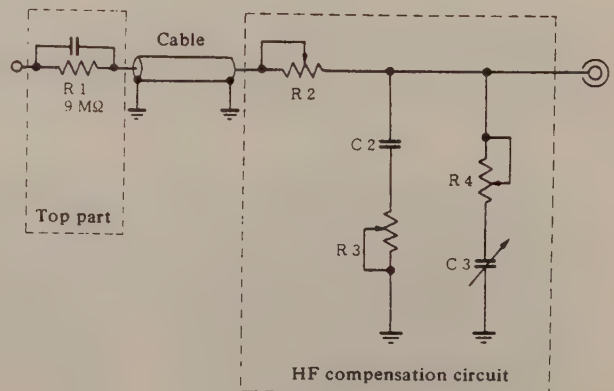
The calibration procedures for the 5 mV range are identical to those of the 10 mV range in steps (1), (2) and (3) above, except that the VOLTS/CM switch is set to the 5 mV position and the calibration capacitors are C62A/B in this step (refer to Fig. 6-9).

Frequency Characteristics Check After the squarewave calibration procedure is complete, check the frequency characteristics in the 5 mV and 10 mV ranges. Connect the signal generator output to the vertical INPUT. Adjust the signal generator frequency to 10 MHz, set the output so that the display amplitude is 4 cm on the graticule, and read the output level. Change the generator frequency to 300 MHz in the 10 mV range, and 250 MHz in the 5 mV range, and adjust the output level meter for the same indication as at 10 MHz. The display amplitude should be above 2.85 cm (−3 dB) at 300 MHz or 250 MHz.

Probe Adjustment

If the phase and high frequency characteristics of the probe are incorrect, erroneous measurements will result. The probe phase and high frequency compensation circuits are calibrated by the following procedures.

Fig. 6-18 HF Compensation Circuit in Probe 1022



Phase Calibration Connect the probe connector to the INPUT, remove the tip from the probe, and connect the probe tip to the CAL OUT jack. Set the VOLTS/CM switch to the 10 mV range, CAL switch to 0.5, and adjust the vertical gain for a display amplitude of 5 cm on the CRT traticule.

The flatness of the waveform top varies as shown in Fig. 6-14, as the phase calibration trimmer in Fig. 3-6 is adjusted.

Set the trimmer for the optimum waveform display.

High-Frequency Compensator Adjustment Prepare the following test instruments and adapters as shown below.

Square wave Generator	
Rise time	300 psec or less
Output voltage	0 to 1 V p-p
Coaxial Cable	
Characteristic impedance	50 ohms
50 ohm Termination Load	(BB 50M1)
BNC-J Adapter	(to be described later)
50 ohm Coaxial Attenuator	(to be described later)

After the probe phase calibration is completed loosen the phase calibration box mounting screw and slide the cover backward, and connect the probe and the test instruments as shown in Fig. 6-15.

The calibration procedures are as follows:

(1) Set the VOLTS/CM switch to the 10 mV position, and the A TIME/CM control to a position which is dependent on the generator frequency and pulse width of the square wave, so that one or two cycles of the squarewave will be displayed on the graticule.

(2) Adjust the squarewave generator output for a vertical amplitude of 4 to 5 cm. If the generator output is excessively large, reduce the signal amplitude by using the 50-ohm coaxial attenuator. The BNC-J adapter will be convenient for the adjustment because it can secure the probe tip tightly. (A HF test jack is separately prepared to connect the probe ground firmly to the chassis in high frequency measurements.)

(3) The variable resistor R2 (in Fig. 6-17) is adjusted for a flat waveform top, as shown in Fig. 6-16 (b), and R3 and R4 (in Fig. 6-17) sharpen the leading edge of the pulses. Waveform distortions, such as overshoot, undershoot and ringing, which result from improper probe cable matching must be minimized through these adjustments.

Repeat the adjustment of R2, R3 and R4 to obtain optimum waveform flatness and rise time and to minimize the distortion. An insulated screwdriver (plastic blade) must be used to prevent the screwdrivers presence from effecting the phase calibration and HF characteristics compensation.

notes

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ORDERING INFORMATION

Replacement parts may be ordered through an IWATSU Representative or directly from the factory. To be certain of receiving the proper parts, always include the following information with the order:

- a. Model Number and serial number of the instrument on which the parts will be installed.
- b. Circuit reference number and subassembly name, if applicable, for which the part is intended. If the part does not have a circuit reference, the description from the parts list should be used.
- c. Iwatsu part number.

For factory repair, contact the IWATSU agent and include the following information:

- a. Model number and serial number of the instrument on which the work is to be performed.
- b. Details concerning the nature of the malfunction, or, type of repair desired.

Shipping instructions will be sent to you promptly.

HOW TO USE THIS PARTS LIST

The parts list is divided into subsections corresponding to the schematic diagrams such as VERTICAL AMP, TRIG

CIRCUIT, SWEEP GENERATOR, HORIZONTAL AMP, CRT CIRCUIT and POWER SUPPLY. Component locations can be determined from the schematic diagrams, each component appears only once in the parts list. At the beginning of each subsection are listed part numbers for any complete subassemblies in that category that are available as replacement parts. These subassemblies may include individually-listed components; care should be taken to locate malfunctions to the lowest possible level of replacement part and thus avoid the time and cost involved in "over-repair".

ABBREVIATIONS

Cap.	Capacitor
cer.	ceramic
elect.	aluminium electrolytic chemical condenser
elect. tan.	tan-talum electrolytic chemical condenser
poly.	polyethytel film condenser
Res.	Resistor
w.w.	wire wound
comp.	composition
FET	Field Effect Transistor
Diode	
T. Diode	Tunnel Diode
Z. Diode	Zenner Diode
Var.	variable

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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VERTICAL INPUT & ATTENUATOR

C1 A/B	Cap., 0.047 μ F, 400 WVDC, ± 20 %, poly.	74130-3820
C2 A/B	Cap., Var., 2 – 6 pF, 500 WVDC, cer.	74110-0990
C3 A/B	Cap., 6 pF, 500 WVDC, ± 0.5 pF, cer.	74050-6090
C4 A/B	Cap., Var., 0.5 – 4 pF, 500 WVDC, polypropylene	74110-0300
C6 A/B	Same as C2 A/B	
C7 A/B	Same as C4 A/B	
C10 A/B	Same as C2 A/B	
C12 A/B	Cap., Var., 0.5 – 1.5 pF, Fluorine Resin	74110-0290
C13 A/B	Cap., 2 pF, 100 WVDC, ± 1 pF, mica	74090-5190
C13Ab	Cap., 4 pF, 500 WVDC, ± 0.25 pF, cer.	74050-0110
C13Bb	Same as C13Ab	
C14 A/B	Same as C2 A/B	
C15 A/B	Same as C12 A/B	
C16 A/B	Cap., 20 pF, 100 WVDC, ± 10 %, mica	74090-5010
C18 A/B	Same as C2 A/B	
C19 A/B	Same as C12 A/B	
C20 A/B	Cap., 50 pF, 100 WVDC, ± 10 %, mica	74090-5020
C22 A/B	Same as C2 A/B	
C23 A/B	Same as C12 A/B	
C24 A/B	Cap., 100 pF, 100 WVDC, ± 10 %, mica	74090-5030
C26 A/B	Same as C2 A/B	
C27 A/B	Same as C12 A/B	
C28 A/B	Cap., 200 pF, 100 WVDC, ± 10 %, mica	74090-5040
C30 A/B	Same as C2 A/B	
C31 A/B	Same as C12 A/B	
C32 A/B	Cap., 500 pF, 100 WVDC, ± 10 %, mica	74090-5050
C34 A/B	Cap., 4 pF, 50 WVDC, ± 0.5 pF, cer.	74050-4720
C35 A/B	Cap., 0.001 μ F, 500 WVDC, +100 – -0 %, cer.	74060-0700
C36 A/B	Cap., Var., 6 – 20 pF, 250 WVDC, cer.	74110-0630
C37 A/B	Cap., 27 pF, 500 WVDC, ± 2 %, cer.	74050-0120
C38 A/B	Same as C12 A/B	
C39Aa	Cap., 1000 pF, 500 WVDC, +100 – -0 %, cer.	74060-0180
C39Ab	Same as C39Aa	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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C39Ba	Same as C39Aa	
C39Bb	Same as C39Aa	
L1 A/B	Inductor	74400-5020
L2 A/B	Inductor	74400-3970
L4 A/B	Inductor	74400-5010
R1 A/B	Res., 500 k, 1/4 W, ± 1 %, carbon	74226-0080
R2 A/B	Res., 1 M, 1/4 W, ± 1 %, carbon	74226-0150
R3 A/B	Res., 43, 1/8 W, ± 5 %, compo.	74257-0890
R5 A/B	Res., 62, 1/8 W, ± 5 %, compo.	74257-0010
R6 A/B	Res., 800 k, 1/4 W, ± 1 %, carbon	74226-0090
R7 A/B	Res., 250 k, 1/4 W, ± 1 %, carbon	74226-0070
R8 A/B	Same as R3 A/B	
R9 A/B	Res., 8.2, 1/8 W, ± 5 %, compo.	74257-0880
R10 A/B	Res., 900 k, 1/4 W, ± 1 %, carbon	74226-0100
R11 A/B	Res., 111 k, 1/4 W, ± 1 %, carbon	74226-0060
R12 A/B	Same as R3 A/B	
R13 A/B	Res., 82, 1/8 W, ± 5 %, compo.	74257-0880
R14 A/B	Res., 950 k, 1/4 W, ± 1 %, carbon	74226-0110
R15 A/B	Res., 52.6 k, 1/4 W, ± 1 %, carbon	74226-0050
R16 A/B	Same as R3 A/B	
R17 A/B	Res., 68, 1/8 W, ± 5 %, compo.	74257-0790
R18 A/B	Res., 980 k, 1/4 W, ± 1 %, carbon	74226-0120
R19 A/B	Res., 20.4 k, 1/4 W, ± 1 %, carbon	74226-2590
R20 A/B	Same as R3 A/B	
R21 A/B	Res., 56, 1/8 W, ± 5 %, compo.	74257-0150
R22 A/B	Res., 990 k, 1/4 W, ± 1 %, carbon	74226-0130
R23 A/B	Res., 10.1 k, 1/4 W, ± 1 %, carbon	74226-2610
R24 A/B	Same as R3 A/B	
R25 A/B	Same as R21 A/B	
R26 A/B	Res., 995 k, 1/4 W, ± 1 %, carbon	74226-0140
R27 A/B	Res., 5.03 k, 1/4 W, ± 1 %, carbon	74226-0020
R28 A/B	Same as R3 A/B	
R29 A/B	Res., 43, 1/8 W, ± 5 %, compo.	74257-0890
R34 A/B	Res., 100, 1/8 W, ± 5 %, compo.	74257-0700
R30 A/B	Res., 998 k, 1/4 W, ± 1 %, carbon	74226-1790
R31 A/B	Res., 2 k, 1/4 W, ± 1 %, carbon	74226-2190
R32 A/B	Same as R3 A/B	
R33 A/B	Res., 33, 1/8 W, ± 5 %, compo.	74257-0850
R35 A/B	Res., 470 k, 1/4 W, ± 5 %, compo.	74253-1570
R36Aa	Res., 100 k, 1/4 W, ± 5 %, metal	74230-0260
R36Ab	Res., 130, 1/8 W, ± 5 %, compo.	74257-0840
R36Ba	Same as R36Aa	
R36Bb	Same as R36Ab	
R37 A/B	Same as R10 A/B	
R38 A/B	Res., 10, 1/8 W, ± 5 %, compo.	74257-0020
R39 A/B	Same as R3AB	
S1 A/B	Switch, Lever	74440-1260
S2AB	Switch, Rotary	74431-6412

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
J1 A/B	Connector, UG625/U-Ni, BNC receptacle	74500-2530	C80A	Same as C60A	
J2 AB	Connector, 1150-3RF-X,	74500-3880	C81Aa	Same as C44A	
TB1	Terminal	74510-0140	C81Ab	Cap., Var., 6 — 20 pF, 250 WVDC, cer.	74110-0730
CH1 PREAMPLIFIER			C82A	Same as C52A	
			C83A	Same as C52A	
			C84Aa	Same as C54A	
			C84Ab	Same as C55Ab	
C40A	Cap., 0.01 μ F, 25 WVDC, +80 — -20 %, cer.	74060-0560	L20A	Inductor	74470-0950
C41A	Same as C40A		L21A	Same as L20A	
C42A	Cap., 2 pF, 50 WVDC, $\pm$ 0.5 pF, cer.	74050-1690	L30A	Inductor, Ferrite Bead Core,	74560-1240
C43A	Same as C40A		L31A	Same as L30A	
C44A	Cap., Var., 5 — 20 pF, 50 WVDC, cer.	74050-1800	L32A	Same as L30A	
C45A	Same as C44A		L33A	Same as L30A	
C46A	Cap., 300 pF, 50 WVDC, +80 — -20 %, cer.	74050-1800	L55A	Same as L30A	
C47A	Same as C46A		R41A	Res., 7.5 k, 1/4 W, $\pm$ 5 %, metal	74230-0570
C48A	Cap., 3 pF, 50 WVDC, $\pm$ 5 pF, cer.	74050-5450	R42A	Res., 10, 1/4 W, $\pm$ 5 %, metal	74230-0070
C49A	Same as C48A		R43A	Same as R41A	
C50A	Same as C40A		R44A	Same as R42A	
C51A	Same as C40A		R45A	Res., 3 k, 1/4 W, $\pm$ 5 %, metal	74230-0530
C52A	Cap., 0.001 μ F, 50 WVDC, +80 — -20 %, cer.	74060-1750	R46A	Res., 100, 1/4 W, $\pm$ 5 %, metal	74230-0130
C53A	Same as C52A		R47A	Res., Var., 5 k, metal	74349-1580
C54A	Cap., 0.01 μ F, 500 WVDC, +100 — -0 %, cer.	74060-0730	R52A	Res., 10 k, 1/4 W, $\pm$ 5 %, metal	74230-0120
C55Aa	Same as C40A		R60A	Res., 110, 1/4 W, $\pm$ 5 %, metal	74230-1520
C55Ab	Cap., 0.02 μ F, 50 WVDC, +80 — -20 %, cer.	74060-0580	R61A	Res., Var., 100, metal	74349-0830
C56A	Cap., 0.0022 μ F, 500 WVDC, +100 — -0 %, cer.	74060-0840	R62A	Res., 910 or 1 k, 1/4 W, $\pm$ 5 %, metal	74230-0490 or 74230-1260
C58A	Same as C40A		R63A	Same as R62A	
C59A	Same as C40A		R64A	Res., 200 or 220 or 240, 1/4 W, $\pm$ 5 %, metal	74230-0910 or 74230-1160 or 74230-0410
C60A	Cap., Var., 2 — 7 pF, 50 WVDC, cer.	74110-0770	R65A	Same as R64A	
C62A	Cap., Var., 3 — 10 pF, 50 WVDC, cer.	74110-0750	R66A	Res., 910, 1/4 W, $\pm$ 5 %, metal	74230-1260
C63A	Same as C52A		R67A	Same as R66A	
C64A	Same as C52A		R68A	Res., 820, 1/4 W, $\pm$ 5 %, metal	74230-0490
C65A	Same as C52A		R69A	Res., 680, 1/4 W, $\pm$ 5 %, metal	74230-0150
C66A	Same as C52A		R70A	Res., 1.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0500
C68A	Cap., 10 μ F, 16 WVDC, elect.	74120-3110	R71A	Res., Var., 1 k, carbon	74322-2230
C70A	Same as C62A		(with S71A)		
C71A	Same as C44A		R72Aa	Res., 36, 1/4 W, $\pm$ 5 %, metal	74230-1490
C72A	Same as C52A		R72Ab	Same as R72Aa	
C73A	Same as C52A		R73A	Res., 220, 1/4 W, $\pm$ 5 %, metal	74230-0480
C74A	Cap., 4 pF, 50 WVDC, $\pm$ 0.5 pF, cer.	74050-4720	R74A	Same as R73A	
C75A	Same as C74A		R75A	Same as R60A	
			R76A	Same as R60A	
			R77A	Res., 82, 1/4 W, $\pm$ 5 %, metal	74230-1070
			R78A	Same as R69A	
			R79A	Res., 1 k, 1/4 W, $\pm$ 5 %, metal	74230-0030
			R80A	Res., 30, 1/4 W, $\pm$ 5 %, metal	74230-0080
			R81A	Same as R80A	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R82A	Res., 200, 1/4 W, $\pm 5\%$, metal	74230-1340
R83A	Same as R82A	
R84A	Same as R82A	
R85A	Res., 91, 1/4 W, $\pm 5\%$, metal	74230-1230
R86A	Same as R61A	
R87A	Same as R46A	
R88A	Res., 120, 1/4 W, $\pm 5\%$, metal	74230-1130
R89A	Same as R88A	
R90A	Res., 15 k, 1/4 W, $\pm 2\%$, carbon	74244-0100
R91A	Same as R90A	
R92A	Same as R60A	
R93A	Same as R60A	
R94A	Res., 100 k, 1/4 W, $\pm 5\%$, metal	74230-0260
R95Aa	Res., 150 k, 1/4 W, $\pm 5\%$, metal	74230-0510
R95Ab	Same as R95Aa	
R96A	Res., 15 k, 1/4 W, $\pm 5\%$, metal	74230-0140
R97A	Res., Var., 30 k, carbon	74321-0220
R98A	Res., 56, 1/4 W, $\pm 5\%$, metal	74230-0940
R99A	Same as R98A	
R100a	Same as R79A	
R102A	Res., 91, 1/8 W, $\pm 5\%$, compo.	74257-0870
R103A	Same as R102A	
R104A	Res., 470, 1/4 W, $\pm 5\%$, metal	74230-0160
R105A	Res., 10 k, 1/4 W, $\pm 2\%$, carbon	74244-0090
R110A	Same as R46A	
R111A	Res., Var., 500, metal	74349-0760
R112A	Res., 560, 1/4 W, $\pm 5\%$, metal	74230-0580
R113A	Same as R112A	
R114A	Res., 130, 1/4 W, $\pm 5\%$, metal	74230-1150
R115A	Same as R114A	
R116A	Same as R61A	
R117A	Res., 24, 1/4 W, $\pm 5\%$, metal	74230-1600
R120A	Same as R46A	
R121A	Same as R46A	
R128A	Res., 15, 1/4 W, $\pm 5\%$, metal	74230-1170
R129A	Same as R128A	
R130A	Res., 47, 1/4 W, $\pm 5\%$, metal	74230-0100
R131A	Same as R130A	
R132A	Res., 20 k, 1/4 W, $\pm 5\%$, metal	74230-0310
R133A	Same as R132A	
R134A	Res., 1.8 k, 1/4 W, $\pm 5\%$, metal	74230-0810
R135A	Same as R134A	
R137A	Res., Var., 10 k + 10 k, carbon	74322-2250
R140A	Res., 180, 1/4 W, $\pm 5\%$, metal	74230-0860
R141Aa	Same as R111A	
R141Ab	Res., Var., 5 k, metal	74349-0550
R143A	Res., Var., 50, metal	74349-1590
R145A	Same as R114A	
R146A	Same as R114A	
R147A	Res., 1.5 k, 1/4 W, $\pm 5\%$, metal	74230-0110
R148A	Same as R147A	
R142A	Res., 620, 1/4 W, $\pm 2\%$, carbon	74244-0490

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R144A	Same as R142A	
D1A	Diode, 1S 1544, Selected,	74040-3630
D3A	Z. Diode, RD 6A	74040-0790
D5A	Diode, 1S 1992, Selected,	74040-3930
D6A	Same as D5A	
D7A	Diode, 1S 1458	74040-2920
D8A	Same as D7A	
TR1A	FET, 2N 4416, Selected,	74030-4590
TR2A	Same as TR1A	
TR3A	Transistor, MM4049, Selected,	74030-4210
TR4A	Same as TR3A	
TR5A	Transistor, MM4049, Selected,	74030-4210
TR6A	Same as TR5A	
TR9A	Transistor, 2SC 989, Selected,	74030-4970
TR10A	Same as TR9A	
TR11Aab	Transistor, N501-BFY	74030-4780
TR12A	Same as TR9A	
TR13A	Same as TR9A	
TR14A	Same as TR9A	
TR15A	Same as TR9A	
NE1A	Neon Lamp, NE 2	74020-1110
	Neon Lamp Socket	74480-1490
S71A	Reference R71A	

CH2 PREAMPLIFIER

C40B	Cap., 0.01 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0560
C41B	Same as C40B	
C42B	Cap., 2 pF, 50 WVDC, ± 0.5 pF, cer.	74050-1690
C43B	Same as C40B	
C44B	Cap., Var., 5 - 20 pF, 50 WVDC, cer.	74110-0780
C45B	Same as C44B	
C46B	Cap., 300 pF, 50 WVDC, $\pm 5\%$, cer.	74050-1800
C47B	Same as C46B	
C48B	Cap., 3 pF, 50 WVDC, ± 0.5 pF, cer.	74050-5450
C49B	Same as C48B	
C52B	Cap., 0.001 μ F, 50 WVDC, +80 - -20 % cer.	74060-0750
C53B	Same as C52B	
C54B	Cap., 0.01 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0730
C55Ba	Same as C40B	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C55Bb	Same as C40B		R60B	Res., 110, 1/4 W, $\pm 5\%$, metal	74230-1520
C56B	Cap., 0.0022 μ F, 500 WVDC, +100 - 0 %, cer.	74060-0840	R61B	Res., Var., 100, metal	74349-0830
C58B	Same as C40B		R62B	Res., 910 or 1 k, 1/4 W, $\pm 5\%$, metal	74230-1260 or 74230-0490
C59B	Same as C40B		R63B	Same as R62B	
C60B	Cap., Var., 2 - 7 pF, 50 WVDC, cer.	74110-0770	R64B	Res., 200 or 220 or 240, 1/4 W, $\pm 5\%$, metal	74230-0910 or 74230-1160 or 74230-0470
C62B	Cap., Var., 3 - 10 pF, 50 WVDC, cer.	74110-0750	R65B	Same as R64B	
C63B	Same as C52B		R66B	Res., 910, 1/4 W, $\pm 5\%$, metal	74230-1260
C64B	Same as C52B		R67B	Same as R66B	
C65B	Same as C52B		R68B	Same as R51B	
C66B	Same as C52B		R69B	Res., 680, 1/4 W, $\pm 5\%$, metal	74230-0150
C67B	Same as C40B		R70B	Res., 1.2 k, 1/4 W, $\pm 5\%$, metal	74230-0500
C70B	Same as C62B		R71B	Res., Var., 1 k, carbon	74322-2230
C71B	Same as C44B			(with S71B)	
C72B	Same as C52B		R72Ba	Res., 39, 1/4 W, $\pm 5\%$, metal	74230-1490
C73B	Same as C52B		R72Bb	Same as R72Ba	
C74B	Cap., 4 pF, 50 WVDC, ± 0.5 pF, cer.	74050-4720	R73B	Res., 220, 1/4 W, $\pm 5\%$, metal	74230-0480
C75B	Same as C74B		R74B	Same as R73B	
C80B	Same as C60B		R75B	Same as R60B	
C81Ba	Same as C44B		R76B	Same as R60B	
C81Bb	Cap., Var., 6 - 20 pF, 250 WVDC, cer.	74110-0730	R77B	Res., 82, 1/4 W, $\pm 5\%$, metal	74230-1090
C82B	Same as C52B		R78B	Same as R69B	
C83B	Same as C52B		R79B	Res., 1 k, 1/4 W, $\pm 5\%$, metal	74230-0030
C84Ba	Same as C54B		R80B	Res., 36, 1/4 W, $\pm 5\%$, metal	74230-1490
C84Bb	Cap., 0.01 μ F, 50 WVDC, +80 - 20%, cer.	74060-0580	R81B	Same as R80B	
C94B	Cap., 1000 pF, 50 WVDC, +100 - 0 %, cer.	74060-1810	R82B	Res., 200, 1/4 W, $\pm 5\%$, metal	74230-1340
C95B	Same as C94B		R83B	Same as R82B	
L20B	Inductor	74470-0950	R84B	Same as R82B	
L21B	Same as L20B		R85B	Res., 91, 1/4 W, $\pm 5\%$, metal	74230-1230
L30B	Inductor, Ferrite Bead Core,	74560-1240	R86B	Same as R61B	
L31B	Same as L30B		R87B	Same as R46B	
L32B	Same as L30B		R88B	Res., 120, 1/4 W, $\pm 5\%$, metal	74830-1130
L33B	Same as L30B		R89B	Same as R88B	
L55B	Same as L30B		R90B	Res., 15 k, 1/4 W, $\pm 2\%$, carbon	74244-0100
R41B	Res., 7.5 k, 1/4 W, $\pm 5\%$, metal	74230-0570	R91B	Same as R90B	
R42B	Res., 10, 1/4 W, $\pm 5\%$, metal	74230-0070	R92B	Same as R60B	
R43B	Same as R41B		R93B	Same as R60B	
R44B	Same as R42B		R94B	Res., 100 k, 1/4 W, $\pm 5\%$, metal	74230-0260
R45B	Res., 3 k, 1/4 W, $\pm 5\%$, metal	74230-0530	R95Ba	Res., 150, 1/4 W, $\pm 5\%$, metal	74230-0510
R46B	Res., 100, 1/4 W, $\pm 5\%$, metal	74230-0130	R95Bb	Same as R95Ba	
R47B	Res., Var., 5 k, metal	74349-1580	R96B	Res., 15 k, 1/4 W, $\pm 5\%$, metal	74230-0140
R50B	Same as R42B		R97B	Res., Var., 30 k, carbon	74321-0220
R51B	Res., 820, 1/4 W, $\pm 5\%$, metal	74230-0490	R98B	Res., 56, 1/4 W, $\pm 5\%$, metal	74230-0940
R52B	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120	R99B	Same as R98B	
			R100B	Same as R79B	
			R102B	Res., 91, 1/8 W, $\pm 5\%$, compo.	74257-0870
			R103B	Same as R102B	
			R104B	Res., 470, 1/4 W, $\pm 5\%$, metal	74230-0160
			R105B	Res., 10 k, 1/4 W, $\pm 5\%$, compo.	74244-0090
			R110B	Same as R46B	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R111B	Res., Var., 500, metal	74349-0760
R112B	Res., 560, 1/4 W, $\pm 5\%$, metal	74230-0580
R113B	Same as R112B	
R114B	Res., 130, 1/4 W, $\pm 5\%$, metal	74230-1150
R115B	Same as R114B	
R116B	Same as R61B	
R120B	Same as R46B	
R121B	Same as R46B	
R122B	Same as R46B	
R123B	Same as R46B	
R124B	Res., 51 k, 1/4 W, $\pm 5\%$, metal	74230-1010
R125B	Same as R124B	
R126B	Same as R52B	
R127B	Res., Var., 20 k, metal	74349-1530
R128B	Res., 15, 1/4 W, $\pm 5\%$, metal	74230-1170
R129B	Same as R128B	
R130B	Res., 47, 1/4 W, $\pm 5\%$, metal	74230-0100
R131B	Same as R130B	
R132B	Res., 20 k, 1/4 W, $\pm 5\%$, metal	74230-0310
R133B	Same as R132B	
R134B	Res., 1.8 k, 1/4 W, $\pm 5\%$, metal	74230-0810
R135B	Same as R134B	
R136B	Res., Var., 10 k + 10 k + 500, carbon	74322-2240
R140B	Res., 180, 1/4 W, $\pm 5\%$, metal	74230-0860
R141Ba	Same as R111B	
R141Bb	Res., Var., 5 k, metal	74349-0550
R142B	Res., 620, 1/4 W, $\pm 2\%$, carbon	74244-0490
R143B	Res., Var., 50, metal	74349-1590
R144B	Same as R142B	
R145B	Same as R114B	
R146B	Same as R114B	
R147B	Res., 1.5 k, 1/4 W, $\pm 5\%$, metal	74230-0110
R148B	Same as R147B	
D1B	Diode, 1S 1544	74040-3630
D3B	Z. Diode, RD6A	74040-0790
D4B	Same as D3B	
D5B	Diode, 1S 1992, Selected,	74040-3930
D6B	Same as D5B	
D7B	Diode, 1S 1458	74040-2920
D8B	Same as D7B	
D9B	Same as D7B	
D10B	Same as D7B	
D11B	Same as D7B	
D12B	Same as D7B	
D13B	Same as D7B	
D14B	Same as D7B	
D15B	Same as D7B	
D16B	Same as D7B	
TR1B	FET, 2N4416, Selected,	74030-0590

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
TR2B	Same as TR1B	
TR3B	Transistor, MM4049, Selected,	74030-4210
TR4B	Same as TR3	
TR5B	Transistor, MM4049, Selected,	74030-4210
TR6B	Same as TR5B	
TR9B	Transistor, 2SC 989, Selected,	74030-4970
TR10B	Same as TR9B	
TR11 Bab	Transistor, N501-BFY, Selected,	74030-4780
TR12B	Same as TR9B	
TR13B	Same as TR9B	
TR14B	Same as TR9B	
TR15B	Same as TR9B	
S71B	Reference R71B	
S120B	Switch, Lever	74440-1790
NE1B	Neon Lamp, NE-2	74020-1110
	Neon Lamp Socket	74480-1490
VERTICAL SWITCHING CIRCUIT		
C92	Cap., 0.001 μ F, 50 WVDC, +80 - -20 %, cer.	74060-1750
C93	Same as C92	
C94	Cap., 10 pF, 50 WVDC, $\pm$ 1 pF, cer.	74050-1700
C95	Same as C94	
C101	Cap., 0.0033 μ F, 50 WVDC, $\pm$ 10 %, poly.	74130-2830
C102	Cap., 200 pF, 50 WVDC, $\pm$ 5 %, cer.	74050-4750
C103	Cap., 150 pF, 50 WVDC, $\pm$ 5 %, cer.	74050-3010
C104	Same as C103	
C105	Cap., 0.05 μ F, 25 WVDC, +80 - -20 %, cer.	74060-1220
C106	Same as C105	
C107	Cap., 10 μ F, 25 WVDC, elect.	74120-0830
C108	Same as C107	
C109	Same as C105	
C110	Same as C105	
C111	Cap., 0.0022 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0840
C131	Cap., 0.01 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0560
C132	Same as C131	
C133	Same as C131	
C134	Same as C131	
C135	Same as C131	
C136	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C140a	Cap., 0.02 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0570
C140b	Cap., 47 μ F, 16 WVDC, elect.	74120-3090
C141a	Same as C140a	
C141b	Same as C140b	
C142	Cap., 0.0047 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0770
C191	Same as C131	
C192	Same as C131	
L40	Inductor, Ferrite Bead Core,	74560-1240
L41	Same as L40	
L42	Inductor	74400-0740
L43	Same as L42	
L101	Same as L42	
L102	Same as L42	
L140	Same as L42	
L141	Same as L42	
L142	Same as L42	
R151	Res., 820, 1/4 W, $\pm$ 5 %, metal	74230-0490
R152	Same as R151	
R153	Res., 1 k, 1/4 W, $\pm$ 5 %, metal	74230-0030
R154	Same as R153	
R155	Res., 470, 1 W, $\pm$ 2 %, carbon	74242-0220
R156	Res., 470, 1/4 W, $\pm$ 5 %, metal	74230-0160
R157	Same as R156	
R158	Res., 150, 1/4 W, $\pm$ 5 %, metal	74230-0510
R159	Same as R158	
R161	Res., 30, 1/4 W, $\pm$ 5 %, metal	74230-0080
R162	Res., 27, 1/8 W, $\pm$ 5 %, compo.	74257-0410
R163	Same as R162	
R165	Same as R161	
R166	Same as R161	
R171	Same as R156	
R172	Res., 6.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0890
R173	Res., 360, 1/4 W, $\pm$ 5 %, metal	74230-1110
R174	Res., 20, 1/4 W, $\pm$ 5 %, metal	74230-1140
R175	Same as R173	
R176	Same as R174	
R177	Res., 620, 1/4 W, $\pm$ 5 %, metal	74230-1040
R178	Same as R177	
R179	Res., 240, 1/4 W, $\pm$ 5 %, metal	74230-1250
R180	Same as R179	
R181	Res., 3 k, 1/4 W, $\pm$ 5 %, metal	74230-0530
R182	Same as R181	
R183	Res., 7.5 k, 1/4 W, $\pm$ 5 %, metal	74230-0570
R184	Res., 2.7 k, 1/4 W, $\pm$ 5 %, metal	74230-0420
R185	Same as R184	
R186	Res., 180, 1/4 W, $\pm$ 5 %, metal	74230-0860
R187	Same as R186	
R189	Res., 160, 1/4 W, $\pm$ 5 %, metal	74230-1410

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R190	Same as R153	
R191	Res., 10 k, 1/4 W, $\pm$ 5 %, metal	74230-0120
R192	Res., 1.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0500
R193	Same as R153	
R194	Same as R191	
R195	Res., 820, 1/4 W, $\pm$ 5 %, metal	74230-0490
D20 A/B	Diode, 1S 1458	74040-2920
D21 A/B	Same as D20 A/B	
D22 A/B	Same as D20 A/B	
D23 A/B	Same as D20 A/B	
D30	Diode, SD15	74040-1050
D31	Diode, 1S 953	74040-1720
D32	Same as D31	
D33	Same as D31	
D34	Same as D31	
D35	Same as D31	
D179	Same as D31	
D180	Same as D31	
D190	Same as D31	
TR16	Transistor, 2SC 989, Selected,	74030-4970
TR17	Same as TR16	
TR18	Transistor, 2N 4121	74030-2990
TR19	Same as TR18	
TR20	Same as TR18	
TR21	Same as TR18	
TR22	Transistor, 2N 4275	74030-3160
S150	Switch, Rotary	74431-6302
J20	Connector	74500-3870
J21	Same as J20	
P20	Connector	74500-3860
P21	Same as P20	
P30	Connector, 24 Pin,	74500-0430
T180	Transformer	74400-4730

TRIGGER AMPLIFIER (1)

C201 A/B	Cap., 5 pF, 50 WVDC, $\pm$ 5 pF, cer.	74050-2620
C202 A/B	Cap., 0.001 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0750
C203 A/B	Same as C202 A/B	
C220 A/B	Cap., 10 pF, 50 WVDC, $\pm$ 1 pF, cer.	74050-1700
C221 A/B	Same as C202 A/B	
C222 A/B	Same as C202 A/B	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C240A	Cap., Var., 5 – 20 pF, 50 WVDC, cer.	74110-0780
C240B	Same as C240A	
C241 A/B	Same as C202 A/B	
C242 A/B	Same as C202 A/B	
C251a	Same as C202 A/B	
C251b	Same as C202 A/B	
C252	Cap., 0.01 μ F, 50 WVDC, +80 – -20 %, cer.	74060-0580
L241 A/B	Inductor, Ferrite bead core,	74560-1240
L242 A/B	Same as L241 A/B	
R201 A/B	Res., 91, 1/4 W, $\pm$ 5 %, metal	74230-1230
R202 A/B	Same as R201 A/B	
R203 A/B	Res., 20, 1/4 W, $\pm$ 5 %, metal	74230-1140
R204 A/B	Same as R203 A/B	
R205 A/B	Res., 100, 1/4 W, $\pm$ 5 %, metal	74230-0130
R206 A/B	Res., 1.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0500
R207 A/B	Same as R206 A/B	
R208 A/B	Res., Var., 200, W.W.	74331-0570
R209 A/B	Res., 130, 1/4 W, $\pm$ 5 %, metal	74230-1150
R210 A/B	Same as R209 A/B	
R211 A/B	Res., 120, 1/4 W, $\pm$ 5 %, metal	74230-1130
R212 A/B	Res., 390, 1/4 W, $\pm$ 5 %, metal	74230-0550
R213 A/B	Same as R211 A/B	
R221 A/B	Res., 39, 1/4 W, $\pm$ 5 %, metal	74230-1030
R222 A/B	Same as R221 A/B	
R223 A/B	Same as R205 A/B	
R224 A/B	Res., 1.5 k, 1/4 W, $\pm$ 5 %, metal	74230-0110
R225 A/B	Same as R224 A/B	
R227 A/B	Same as R209 A/B	
R228 A/B	Same as R209 A/B	
R229 A/B	Same as R211 A/B	
R230 A/B	Same as R211 A/B	
R231 A/B	Res., 180, 1/4 W, $\pm$ 5 %, metal	74230-0860
R232 A/B	Res., 47, 1/4 W, $\pm$ 5 %, metal	74230-0100
R233 A/B	Same as R232 A/B	
R234B	Res., 110, 1/4 W, $\pm$ 5 %, metal	74230-1520
R235B	Same as R234B	
R240 A/B	Same as R211 A/B	
R241 A/B	Same as R212 A/B	
R242 A/B	Same as R212 A/B	
R243 A/B	Res., 300, 1/4 W, $\pm$ 5 %, metal	74230-1160
R244 A/B	Same as R243 A/B	
R250	Res., 68, 1/4 W, $\pm$ 5 %, metal	74230-1050
R251	Res., Var., 100, metal	74349-0830
R252	Res., 750, 1/4 W, $\pm$ 5 %, metal	74230-0540
R253	Same as R252	
R254	Res., 680, 1/4 W, $\pm$ 5 %, metal	74230-0150
R255	Same as R254	
R256	Res., 1.6 k, 1/4 W, $\pm$ 5 %, metal	74230-1320

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R257	Same as R256	
R258	Res., Var., 500, metal	74349-1720
R259	Res., 51, 1/4 W, $\pm$ 5 %, metal	74230-0600
TR201 A/B	Transistor, 2N 4260, Selected,	74030-3600
TR202 A/B	Same as TR201 A/B	
TR203 A/B	Same as TR201 A/B	
TR204 A/B	Same as TR201 A/B	
TR205 A/B	Transistor, 2N 5179, Selected	74030-4310
TR206 A/B	Same as TR205 A/B	
TR207	Same as TR205 A/B	
TR208	Same as TR205 A/B	

TRIGGER AMPLIFIER (2)

C261	Cap., 5 pF, 50 WVDC, $\pm$ 0.5 pF, cer.	74050-2620
C262	Cap., 0.001 μ F, 50 WVDC, +80 – -20 %, cer.	74060-1750
C263	Same as C262	
C264 A,B	Cap., 0.01 μ F, 25 WVDC, +80 – -20 %, cer.	74060-0560
C265	Same as C264 A,B	
C266	Same as C264 A,B	
C267	Cap., 10 μ F, 25 WVDC, elect.	74120-0830
C280	Cap., 10 pF, 50 WVDC, $\pm$ 1 pF, cer.	74050-1700
C281	Same as C262	
C285	Same as C264 A,B	
C286	Same as C264 A,B	
C287	Same as C267	
C291	Same as C280	
C291a	Same as C264 A,B	
C292	Same as C262	
C292a	Same as C264 A,B	
C292b	Same as C264 A,B	
C292c	Cap., 0.01 μ F, 500 WVDC, +100 – -20 %, cer.	74060-0730
C292d	Cap., 0.0047 μ F, 500 WVDC, +100 – -20 %, cer.	74060-0770
L260	Inductor	74470-0950
L280	Same as L260	
L291	Inductor	74400-4740
L292	Inductor, Ferrite bead core,	74560-1240
L293	Same as L291	
L294	Same as L291	
R260	Res., 100, 1/4 W, $\pm$ 5 %, metal	74230-0130
R261	Same as R260	
R262	Res., 30, 1/4 W, $\pm$ 5 %, metal	74230-0080
R263	Res., 160, 1/4 W, $\pm$ 5 %, metal	74230-1410

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R264	Res., Var., 200, metal	74349-0770
R265	Res., 1.3 k, 1/4 W, $\pm 5\%$, metal	74230-1330
R266	Same as R265	
R267	Res., 130, 1/4 W, $\pm 5\%$, metal	74230-1150
R268	Same as R267	
R269	Res., 510, 1/4 W, $\pm 5\%$, metal	74230-0450
R270	Same as R269	
R273	Same as R262	
R273AB	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120
R274	Res., 430, 1/4 W, $\pm 5\%$, metal	74230-1300
R276	Res., 91 k, 1/4 W, $\pm 5\%$, metal	74230-1000
R281	Res., 470, 1/4 W, $\pm 5\%$, metal	74230-0160
R282	Res., 240, 1/4 W, $\pm 5\%$, metal	74230-1250
R284	Res., Same as R281	
R285	Same as R281	
R286	Same as R281	
R287	Res., Var., 100, metal	74349-1400
R290	Res., 47, 1/4 W, $\pm 5\%$, metal	74230-0100
R291	Res., 510, 1/4 W, $\pm 5\%$, metal	74230-0450
R292	Res., 750, 1/4 W, $\pm 5\%$, metal	74230-0540
R293a	Res., 24, 1/4 W, $\pm 5\%$, metal	74230-1600
R293B	Res., 2 k, 1/4 W, $\pm 5\%$, metal	74230-0410
R293C	Res., 1 k, 1/4 W, $\pm 2\%$, carbon	74244-0050
R295	Res., 100 k, 1/4 W, $\pm 5\%$, metal	74230-0260
R296	Same as R295	
R297	Res., 5.1 k, 1/4 W, $\pm 5\%$, metal	74230-1020
R298	Res., 91, 1/4 W, $\pm 5\%$, metal	74230-1230
R299	Res., 30, 1/4 W, $\pm 5\%$, metal	74230-0080
D260 A/B	Diode, 1S 1458	74040-2920
D261 A/B	Same as D260 A/B	
D262 A/B	Same as D260 A/B	
D263 A/B	Same as D260 A/B	
D290	Same as D260 A/B	
TR260	Transistor, 2N 5179, Selected	74030-4310
TR261	Same as TR260	
TR280	Transistor, 2N 4260, Selected	74030-3600
TR281	Same as TR280	
TR290	Transistor, 2N 5179	74030-4310
S200	Switch, push button	74430-0020
NE270	Neon Lamp, NL-2S	74020-1780
NE290	Neon Lamp, NE2	74020-1110
	Neon Lamp Socket	74480-1490
NE291	Same as NE290	
T290	Transformer	74400-2850

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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VERCIAL MAIN AMPLIFIER

C901	Cap., 62 pF, 50 WVDC, $\pm 10\%$, cer.	74050-6140
C903	Cap., 12 pF, 50 WVDC, $\pm 10\%$, cer.	74050-4450
C904	Cap., 0.001 μ F, 50 WVDC, +80 - -20 %, cer.	74060-1750
C905	Same as C904	
C906	Cap., 20 pF, 50 WVDC, $\pm 5\%$, cer.	74050-5280
C907	Same as C906	
C910	Cap., Var., 5 - 20 pF, 50 WVDC, cer.	74110-0780
C911	Cap., Var., 3 - 10 pF, 50 WVDC, cer.	74110-0750
C912	Same as C904	
C913	Same as C904	
C921	Same as C904	
C922	Cap., Var., 2 - 7 pF, 50 WVDC, cer.	74110-0770
C923	Cap., 0.01 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0560
C924	Same as C923	
C930	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580
C931	Same as C930	
C932	Cap., 10 μ F, 25 WVDC, elect.	74120-3110
C933	Same as C930	
C934	Same as C930	
C935	Cap., 10 μ F, 50 WVDC, elect.	74120-0980
C936	Same as C930	
C937	Same as C930	
C940	Cap., 0.0022 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0840
C952	Cap., 0.01 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0730
L901	Inductor, Ferrite bead core,	74560-1240
L902	Same as L901	
L903	Same as L901	
L904	Same as L901	
L905	Same as L901	
L906	Same as L901	
L907	Same as L901	
L908	Same as L901	
L910	Same as L901	
L911	Same as L901	
L920	Inductor,	74400-3490
L921	Same as L920	
L930	Inductor	74400-4800
L931	Same as L930	
L932	Same as L901	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
L933	Same as L901		R963	Same as R962	
L934	Same as L901		R964	Same as R901	
L935	Same as L901		R965	Res., 330, 2 W, $\pm 2\%$, carbon	74243-0210
			R966	Same as R965	
R901	Res., 75, 1/4 W, $\pm 5\%$, metal	74230-0880	R967	Res., 10, 1/4 W, $\pm 5\%$, metal	74230-0070
R902	Same as R901		R970	Res., 24, 1/4 W, $\pm 5\%$, metal	74230-1600
R903	Res., 27, 1/8 W, $\pm 5\%$, compo.	74257-1000	R971	Same as R970	
R904	Same as R903		R972	Same as R929	
R905	Res., 68, 1/4 W, $\pm 5\%$, metal	74230-1050	R973	Same as R901	
R908	Res., 3.3 k, 1/4 W, $\pm 5\%$, metal	74230-0350	R980	Res., 70, $\pm 2\%$, For μ wave use, carbon	74271-0670
R909	Res., 560, 1/4 W, $\pm 5\%$, metal	74230-0580	R981	Same as R980	
R910	Res., Var., 100, W.W.	74331-0690	R982	Same as R980	
R911	Same as R909		R983	Same as R980	
R912	Res., 180, 1/4 W, $\pm 5\%$, metal	74230-0860	R984	Res., Var., 100, metal	74349-1400
R913	Same as R912		R985	Res., 62, 1/2 W, $\pm 2\%$, carbon	74241-0150
R920	Res., 3 k, 1/4 W, $\pm 5\%$, metal	74230-0530	R986	Same as R985	
R921	Same as R920				
R922	Res., 1.6 k, 1/4 W, $\pm 5\%$, metal	74230-1320	D901	Diode, 1S 1458	74040-2920
R923	Same as R922		D902	Same as D902	
R924	Res., 820, 1/4 W, $\pm 5\%$, metal	74230-0490			
R925	Same as R924		TR901	Transistor, 2SC 989	74030-4970
R926	Res., 160, 1/4 W, $\pm 5\%$, metal	74230-1410	TR902	Same as TR901	
R927	Same as R926		TR903	Transistor, 2SC 989, Selected	74030-4970
R928	Res., 100 k, 1/4 W, $\pm 5\%$, metal	74230-0260	TR904	Same as TR903	
R929	Res., 100, 1/4 W, $\pm 5\%$, metal	74230-0130	TR905	Transistor, 2N 5179, Selected	74030-4310
R930	Same as R929		TR906	Same as TR905	
R931	Res., 200, 1/4 W, $\pm 5\%$, metal	74230-1340	TR907	Transistor, BFW30	74030-4620
R932	Res., 30, 1/8 W, $\pm 5\%$, compo.	74257-0840		Radiator, TXBF-019-025	74030-2580
R933	Same as R932		TR908	Same as TR907	
R934	Same as R928		TR909	Transistor 2SC 857 $\oplus$	74030-4270
R940	Same as R905		TR910	Same as TR909	
R941	Res., Var., 50, metal	74349-0160	TR911	Same as TR907	
R942	Res., Var., 500, metal	74349-0760	TR912	Same as TR907	
R943	Res., 270, 1/4 W, $\pm 5\%$, metal	74230-0910	TR913	Transistor, 2N 5109	74030-4610
R944	Same as R943			Radiator, 1G-46020	74030-1960
R945	Res., 20, 1/4 W, $\pm 5\%$, metal	74230-1140	TR914	Same as TR913	
R946	Same as R945				
R947	Res., 110, 1/4 W, $\pm 5\%$, metal	74230-1520	S901	Switch, Slide	74430-0600
R948	Same as R947				
R950	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120	NE901	Neon Lamp, NE-68	74020-1170
R951	Same as R950			Neon Lamp Socket	74480-1490
R952	Res., Var., 1 k, carbon	74349-0640	NE902	Same as NE901	
R953	Res., Var., 10 k, carbon	74349-0660			
R954	Res., 91 k, 1/4 W, $\pm 5\%$, metal	74230-1000			
R955	Same as R954				
R956	Same as R950				
R957	Same as R950				
R958	Res., 30, 1/4 W, $\pm 5\%$, metal	74230-0080			
R959	Res., 2.2 k, 1/4 W, $\pm 5\%$, metal	74230-0270			
R960	Res., 22, 1/8 W, $\pm 5\%$, compo.	74257-0130			
R961	Same as R960				
R962	Res., 1 k, 1/2 W, $\pm 2\%$, carbon	74241-0440			

A TRIGGER GENERATOR

C 301	Cap., 2 pF, 500 WVDC, ± 0.5 pF, cer.	74050-1900
C302	Cap., 3 pF, 500 WVDC, ± 0.5 pF, cer.	74050-3870

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C304	Cap., 0.01 uF, 500 WVDC, +100 - 0%, cer.	74060-0730	L310	Same as L309	
C305	Cap., 47 pF, 500 WVDC, ± 10 %, cer.	74050-2080	L311	Same as L301	
C306	Cap., 270 pF, 50 WVDC, ± 10 %, cer.	74050-4570	R301	Res., 22, 1/4 W, ± 5 %, compo.	74253-0690
C307	Cap., Var., 5.5 - 25 pF, 350 WV, cer.	74110-0110	R303	Res., 910 k, 1/4 W, ± 5 %, compo.	74253-1380
C308	Same as C305		R304	Res., 110 k, 1/4 W, ± 5 %, compo.	74253-1300
C309	Cap., 0.1 uF, 25 WVDC, +80 - 20 %, cer.	74060-2330	R305	Res., 27 k, 1/4 W, ± 5 %, compo.	74253-1470
C310	Same as C309		R306	Res., 100 k, 1/4 W, ± 5 %, compo.	74253-1290
C311	Cap., 20 pF, 50 WVDC, ± 5 %, cer.	74050-5280	R307	Res., 100 k, 1 W, ± 2 %, carbon	74242-0750
C312	Cap., 15 pF, 50 WVDC, ± 10 %, cer.	74050-1730	R308	Res., 27, 1/4 W, ± 5 %, compo.	74253-0050
C313	Cap., 0.001 uF, 50 WVDC, +80 - 20 %, cer.	74060-1750	R309	Res., 900 k, 1/4 W, ± 1 %, carbon	74226-0100
C314	Same as C313		R310	Res., 1 k, 1/4 W ± 5 %, metal	74230-0030
C315	Same as C311		R311a	Res., 5.6 k, 1/4 W, ± 5 %, metal	74230-0520
C316	Same as C313		R311b	Res., 2 k, 1/4 W, ± 5 %, metal	74230-0410
C317	Same as C313		R312	Res., Var., 10 k + 10 k (with R504 pushpull switch S304) carbon	74325-2710
C318	Cap., 4 pF, 50 WVDC, ± 0.5 pF, cer.	74050-4720	R313	Res., 9.1 k, 1/4 W, ± 5 %, metal	74230-1090
C319	Same as C313		R314	Res., 680, 1/4 W, ± 5 %, metal	74230-0150
C320	Same as C309		R315	Res., 8.2 k, 1/4 W, ± 5 %, metal	74230-0430
C321	Cap., 0.01 uF, 50 WVDC, +80 - 20 %, cer.	74060-0580	R316	Res., Var., 10 k, carbon	74349-0660
C322	Same as C321		R317	Res., 47, 1/4 W, ± 5 %, metal	74230-0100
C331	Same as C321		R318	Res., 5.1 k, 1/4 W, ± 5 %, metal	74230-1020
C332	Same as C321		R319	Res., 75, 1/4 W, ± 5 %, metal	74230-0880
C333	Cap., 200 pF, 500 WVDC, ± 5 %, cer.	74050-1750	R320	Res., 91, 1/4 W, ± 5 %, metal	74230-1230
C334	Same as C304		R321	Res., 1 k, 1/4 W, ± 5 %, metal	74230-0030
C335	Same as C321		R322	Same as R321	
C336	Same as C333		R323	Res., 130, 1/4 W, ± 5 %, metal	74230-1150
C337	Same as C304		R324	Same as R323	
C338	Cap., 3.3 μ F, 16 WVDC, elect. tan.	74120-1480	R325	Res., 100, 1/4 W, ± 5 %, metal	74230-0130
C339	Same as C309		R326	Same as R325	
C340	Same as C313		R327	Same as R325	
C341	Same as C304		R328	Same as R325	
C342	Same as C313		R329	Res., 240, 1/4 W, ± 5 %, metal	74230-1250
C343	Cap., 10 μ F, 16 WVDC, elect.	74120-3110	R330	Res., 3.6 k, 1/4 W, ± 5 %, metal	74230-1080
C344	Cap., 12 pF, ± 1 pF cer.	74050-5600	R331	Same as R330	
L301	Inductor, Ferrite, bead core,	74560-1240	R332	Res., 30, 1/4 W, ± 5 %, metal	74230-0080
L302	Same as L301		R333	Same as R332	
L303	Same as L301		R334	Res., 3 k, 1/4 W, ± 5 %, metal	
L304	Same as L301		R335	Same as R334	
L305	Same as L301		R336	Res., 24, 1/4 W, ± 5 %, metal	74230-1600
L306	Inductor (coil A)	74400-3712	R337	Same as R336	
L308	Inductor (coil B)	74400-5000	R338	Same as R317	
L309	Inductor	74400-4920	R339	Same as R317	
			R340	Res., 33, 1/4 W, ± 5 %, metal	74230-0280
			R341	Res., Var., 100, metal	74349-0830
			R342	Res., 560, 1/4 W, ± 5 %, metal	74230-0580
			R343	Same as R342	
			R344	Same as R323	
			R345	Same as R340	
			R346	Same as R323	
			R347	Same as R340	
			R348	Res., 68, 1/4 W, ± 5 %, metal	74230-1050

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R350	Res., 1.8 k, 1/4 W, $\pm 5\%$, metal	74230-0810	D314	Same as D311	
R351	Res., 1.8 k, 1/4 W, $\pm 5\%$, metal	74230-0810	D316	Same as D301	
R352	Same as R314		D317	Diode, SD 18	74040-1060
R353	Res., 27, 1/4 W, $\pm 5\%$, metal	74230-1380	D318	Same as D301	
R354a	Res., 750, 1/4 W, $\pm 5\%$, metal	74230-0540	D319	Same as D301	
R354b	Same as R332		D320	Same as D301	
R355	Same as R336		D321	Diode, 1S 953	74040-1720
R361	Res., 910, 1/4 W, $\pm 5\%$, metal	74230-1260	D322	Same as D321	
R363	Same as R353		D323	Same as D321	
R364	Res., 200, 1/4 W, $\pm 5\%$, metal	74230-1340	D324	Same as D321	
R365	Res., 27 k, 1/4 W, $\pm 5\%$, metal	74230-0390	D325	Same as D321	
R366	Same as R364				
R367	Res., 6.8 k, 1/4 W, $\pm 5\%$, metal	74230-0330	TR301a,b	FET, 2N 4416	74030-4590
R368	Res., Var., 1 k, carbon	74349-0640	TR302	Transistor, 2N 4957	74030-4600
R369	Same as R354a		TR303	Same as TR302	
R370	Res., 20, 1/4 W, $\pm 5\%$, metal	74230-1140	TR304	Transistor, 2N 5179	74030-4310
R371	Res., 100, 1/4 W, $\pm 5\%$, metal	74230-0130	TR305	Same as TR304	
R372	Res., 1.6 k, 1/4 W, $\pm 5\%$, metal	74230-1320	TR306	Transistor, 2SC 988	74030-5160
R373	Same as R371		TR307	Same as TR306	
R374	Res., 12 k, 1/4 W, $\pm 5\%$, metal	74230-0440	TR308	Same as TR302	
R375	Res., 300, 1/4 W, $\pm 5\%$, metal	74230-1160	TR309	Same as TR302	
R376b	Res., 7.5 k, 1/4 W, $\pm 5\%$, metal	74230-0570	TR310	Same as TR304	
R377	Res., 56, 1/4 W, $\pm 5\%$, metal	74230-0940	TR311	Same as TR304	
R378	Res., 11 k, 1/4 W, $\pm 5\%$, metal	74230-1550	TR312	Transistor, 2N 4275	74030-3160
R379	Res., 390, 1/4 W, $\pm 5\%$, metal	74230-0550	TR313	Transistor, 2N 4121	74030-2990
R380	Res., 30 k, 1/4 W, $\pm 5\%$, metal	74230-0920	TR314	Same as TR313	
R381	Same as R313		TR315	Same as TR312	
R382	Same as R334				
R383	Res., 1.5 k, 1/4 W, $\pm 5\%$, metal	74230-0110	S301	Switch, Lever (SOURCE)	74440-1802
R384	Res., 270, 1/4 W, $\pm 5\%$, metal	74230-0910	S302	Switch, Lever (COUPLING)	74440-0670
R385	Res., 100 k, 1/4 W, $\pm 5\%$, metal	74230-0260	S303	Switch, Lever (SLOPE)	74440-1880
R386	Same as R385		S304	Reference R312	
R387	Res., 47, 1/4 W, $\pm 5\%$, metal	74230-0100			
R388	Res., 2.4 k, 1/4 W, $\pm 5\%$, metal	74230-0220	T301	Transformer	74400-3890
R389	Res., 3.9 k, 1/4 W, $\pm 5\%$, metal	74230-0090	T302	Same as T301	
R390	Same as R361				
R391	Res., Var., 500, metal	74349-0760	J301	Connector, UG625/U-Ni, BNC receptacle,	74500-2530
R392	Res., 4.3 k, 1/4 W, $\pm 5\%$, metal	74230-1310			
D301	Diode, 1S 1458	74040-2920	A SWEEP GENERATOR		
D302	Z. Diode, RD 6A	74040-0790			
D303	Same as D301		C403	Cap., 0.001 μ F, 25 WVDC, +80 - -20 %, cer.	74060-1750
D304	Same as D301		C410	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580
D305	Same as D301		C411	Cap., 82 pF, 50 WVDC, $\pm 10\%$, cer.	74050-4730
D306	Same as D301		C414	Same as C410	
D307	Same as D301		C421	Cap., 47 pF, 50 WVDC, $\pm 10\%$, cer.	74050-2730
D308	Same as D301		C427	Same as C421	
D309	Same as D301		C429	Cap., 39 pF, 50 WVDC, $\pm 10\%$, cer.	74050-3380
D310	Same as D301		C430	Cap., 10 pF, 50 WVDC, $\pm 10\%$, cer.	74050-1700
D311	T. Diode, 1S 1762	74040-2530			
D312	Diode, 1S 1992	74040-3930			
D313	Same as D312				

A SWEEP GENERATOR

C403	Cap., 0.001 μ F, 25 WVDC, +80 - -20 %, cer.	74060-1750
C410	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580
C411	Cap., 82 pF, 50 WVDC, $\pm$ 10 %, cer.	74050-4730
C414	Same as C410	
C421	Cap., 47 pF, 50 WVDC, $\pm$ 10 %, cer.	74050-2730
C427	Same as C421	
C429	Cap., 39 pF, 50 WVDC, $\pm$ 10 %, cer.	74050-3380
C430	Cap., 10 pF, 50 WVDC, $\pm$ 1 pF, cer.	74050-1700

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C433	Same as C410		R419	Res., 47, 1/4 W, $\pm 5\%$, metal	74230-0100
C439	Cap., 330 pF, 50 WVDC, $\pm 20\%$, cer.	74060-2620	R420	Res., 30 k, 1/4 W, $\pm 5\%$, metal	74230-0920
C440	Same as C403		R422	Res., 1 k, 1/4 W, $\pm 5\%$, metal	74230-0030
C450	Cap., 22 pF, 50 WVDC, $\pm 10\%$, cer.	74050-3050	R423	Res., 12 k, 1/4 W, $\pm 5\%$, metal	74230-0440
C459	Same as C439		R424	Res., 2.4 k, 1/4 W, $\pm 5\%$, metal	74230-0220
C470a	Same as C403		R425	Res., Var., 5 k, metal	74349-1650
C470b	Cap., 33 μ F, 10 WVDC, elect.	74120-3130	R426	Res., 100, 1/4 W, $\pm 5\%$, metal	74230-0130
C472	Cap., 0.02 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0660	R427	Same as R422	
C473	Same as C472		R428	Same as R423	
C474	Same as C410		R429	Res., 56, 1/4 W, $\pm 5\%$, metal	74230-0940
C475	Same as C472		R430	Same as R426	
C476	Same as C472		R431	Res., 1.8 k, 1/4 W, $\pm 5\%$, metal	74230-0810
C477	Cap., 0.01 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0340	R432	Same as R419	
C478	Cap., 47 μ F, 16 WVDC, elect.	74120-3090	R433a	Res., 3 k, 1/4 W, $\pm 5\%$, metal	74230-0530
C479	Cap., 0.1 μ F, 25 WVDC, +100 - -0 %, cer.	74060-2330	R433b	Res., 5.1 k, 1/4 W, $\pm 5\%$, metal	74230-1020
C480	Cap., 10 μ F, 16 WVDC, elect.	74120-3110	R434	Same as R424	
C481	Same as C480		R435	Same as R422	
C482	Same as C478		R436	Res., 33 k, 1/4 W, $\pm 5\%$, metal	74230-0300
L401	Inductor	74470-0950	R437	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120
L402	Same as L401		R438	Same as R407c	
L411	Inductor, Ferrite bead core	74560-1240	R439	Res., 240, 1/4 W, $\pm 5\%$, metal	74230-1250
R401	Res., 1.2 k, 1/4 W, $\pm 5\%$, metal	74230-0500	R440A	Res., 200, 1/4 W, $\pm 5\%$, metal	74230-1340
R402	Res., Var., 1 k, metal	74349-1280	R440B	Same as R404	
R403	Res., 220, 1/4 W, $\pm 5\%$, metal	74230-0480	R441	Same as R426	
R404	Res., 4.7 k, 1/4 W, $\pm 5\%$, metal	74230-0290	R442	Res., 22, 1/4 W, $\pm 5\%$, metal	74230-0870
R405	Res., 750, 1/4 W, $\pm 5\%$, metal	74230-0540	R443a	Res., 5.6 k, 1/4 W, $\pm 5\%$, metal	74230-0520
R406	Res., 910, 1/4 W, $\pm 5\%$, metal	74230-1260	R443b	Same as R422	
R407a	Res., 620, 1/2 W, $\pm 5\%$, metal	74230-1570	R443c	Same as R407b	
R407b	Res., 24, 1/4 W, $\pm 5\%$, metal	74230-1600	R443d	Res., 13, 1/4 W, $\pm 5\%$, metal	74230-1740
R407c	Res., 330, 1/4 W, $\pm 5\%$, metal	74230-0470	R443e	Res., 27 k, 1/4 W, $\pm 5\%$, metal	74230-0390
R407d	Res., 75, 1/4 W, $\pm 5\%$, metal	74230-0880	R444a	Res., 3.6 k, 1/4 W, $\pm 5\%$, metal	74230-1080
R407e	Same as R405		R444b	Same as R444a	
R407f	Res., 620, 1/4 W, $\pm 5\%$, metal	74230-1040	R446	Res., 5.6 k, 1 W, $\pm 2\%$, carbon	74242-0460
R410	Res., 33, 1/4 W, $\pm 5\%$, metal	74230-0280	R448	Res., 18 k, 1/4 W, $\pm 5\%$, metal	74230-0460
R411	Res., 3.3 k, 1/4 W, $\pm 5\%$, metal	74230-0350	R449a	Res., 10, 1/4 W, $\pm 5\%$, metal	74230-0070
R412	Res., 1.5 k, 1/4 W, $\pm 5\%$, metal	74230-0110	R449b	Same as R426	
R413	Res., 11 k, 1/4 W, $\pm 5\%$, metal	74230-1550	R450	Res., 12 μ , 1/2 W, $\pm 5\%$, compo.	74253-0840
R414	Res., 43, 1/4 W, $\pm 5\%$, metal	74230-1220	R451	Res., 100 k, 1/4 W, $\pm 5\%$, metal	74230-0260
R415	Same as R410		R452	Same as R407c	
R416	Res., 3.9 k, 1/2 W, $\pm 5\%$, metal	74230-1720	R453A	Same as R439	
R417	Res., 300, 1/4 W, $\pm 5\%$, metal	74230-1160	R453B	Res., 560, 1/4 W, $\pm 5\%$, metal	74230-0580
R418a	Res., 8.2 k, 1/4 W, $\pm 5\%$, metal	74230-0430	R454	Res., 680, 1/4 W, $\pm 5\%$, metal	74230-0150
R418b	Res., 68, 1/4 W, $\pm 5\%$, metal	74230-1050	R455	Res., 360, 1/4 W, $\pm 5\%$, metal	74230-1110
R418c	Res., 120, 1/4 W, $\pm 5\%$, metal	74230-1130	R456	Res., Var., 1 k, W.W.	74331-0580
R418d	Same as R412		R457	Same as R405	
			R458	Res., 1.6 k, 1/4 W, $\pm 5\%$, metal	74230-1320
			R459	Same as R407c	
			R460	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120
			R461a	Res., Var., 2 k, carbon	74349-0880
			R461b	Same as R403	
			R462	Same as R404	
			R464	Same as R404	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R465a	Same as R439		D468	Same as D410b	
R465b	Same as R439		D473	Same as D410b	
R466	Res., 2 k, 1/4 W, $\pm 5\%$, metal	74230-0410	D476	Z. Diode, RD 4A	74040-0760
R467	Res., 22 k, 1/4 W, $\pm 5\%$, metal	74230-0320	D477	Same as D410b	
R468	Res., 43 k, 1/4 W, $\pm 5\%$, metal	74230-1400	D478	Same as D410b	
R469	Res., 51 k, 1/4 W, $\pm 5\%$, metal	74230-1010	D479	Same as D405	
R470	Same as R422		D480	Same as D410b	
R471	Same as R443a				
R472	Same as R419		TR401	Transistor, 2N 4275	74030-3160
R473	Res., 1.2 k, 1/4 W, $\pm 5\%$, metal	74230-0500	TR402	Transistor, 2N 4121	74030-2990
R474	Same as R443a		TR403	Same as TR401	
R475	Same as R422		TR404	Same as TR402	
R476	Same as R437		TR405	Same as TR402	
R477	Same as R407c		TR406	Same as TR401	
R478	Same as R437		TR407	FET, 2SK 12 Y, selected	74030-4050
R479	Res., 1.3 k, 1/4 W, $\pm 5\%$, metal	74230-1330	TR408	Same as TR401	
R480	Same as R466		TR409	Same as TR402	
R481a	Res., 51, 1/4 W, $\pm 5\%$, metal	74230-0600	TR410	Same as TR402	
R481b	Res., 7.5 k, 1 W, $\pm 2\%$, carbon	74242-0490	TR411	Same as TR401	
R481c	Res., 39, 1/4 W, $\pm 5\%$, metal	74230-1030	TR412	Same as TR402	
R482	Res., 47, 1/2 W, $\pm 2\%$, carbon	74241-0120	TR413	Same as TR402	
			TR414	Transistor, 2N 4360	74030-3710
D401	T. Diode, 1S 1760	74040-2900	TR415	Same as TR402	
D405	Diode, 1S 1458	74040-2920	TR416	Same as TR402	
D406	Z. Diode, RD 6A	74040-0790	TR417	Same as TR402	
D410a	Same as D406		TR418	Same as TR401	
D410b	Diode, 1S 953	74040-1720	TR419	Transistor, 2SC 857 $\text{\textcircled{K}}$	74030-4280
D416	Same as D410b		TR420	Same as TR401	
D419a	Same as D406		TR421	Same as TR401	
D419b	Same as D406				
D420	Same as D405		S502	Switch, Rotary	74431-6322
D422	Same as D410b		S503	Switch, Lever	74440-1700
D423	Same as D410b		S550	Switch, Push button	74440-0560
D426	Same as D406			(with Neon Lamp NE469)	
D427	Same as D410b				
D429	Same as D410b		NE469	Reference S550	
D433	Same as D410b				
D435	Same as D405		P301	Connector, 32 Pin	74500-0490
D437	Same as D410b				
D441	Same as D410b				
D443	Same as D410b				
D444a	Same as D410b				
D444b	Same as D410b				
D445	Diode, 1S 467	74040-4140			
D448a	Same as D410b				
D448b	Same as D410b				
D452	Same as D410b				
D453	Same as D410b				
D458	Same as D410b				
D459	Same as D410b				
D462	T. Diode, 1S 1763	74040-2520			
D467	Same as D410b				

TIMING SWITCH A

C501	Cap., 0.01 μ F, 50 WVDC, $\pm 20\%$, cer.	74060-0580
C502A	Cap., 33 pF, 50 WVDC, ± 1 pF, cer.	74050-3910
C502B	Cap., 470 pF, 50 WVDC, $\pm 10\%$, cer.	74050-2430
C502C	Cap., 0.001 μ F, 50 WVDC, $\pm 10\%$, poly.	74130-1310
C502D	Cap., 0.0022 μ F, 50 WVDC, $\pm 10\%$, poly.	74130-2550
C502E	Same as C502D	

B ENDS A CONTROL

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R552	Same as R551	
R553	Res., 5.6 k, 1/4 W, $\pm 5\%$, metal	74230-0520
R554	Res., 5.1 k, 1/4 W, $\pm 5\%$, metal	74230-1020
R555	Res., 6.2 k, 1/4 W, $\pm 5\%$, metal	74230-0890
R556	Res., 4.7 k, 1/4 W, $\pm 5\%$, metal	74230-0290
R557	Res., 2.7 k, 1/4 W, $\pm 5\%$, metal	74230-0420
R558	Res., 3.9 k, 1/4 W, $\pm 5\%$, metal	74230-0090
R559	Same as R553	
R560	Same as R553	
R561	Same as R558	
R562	Res., 75 k, 1/4 W, $\pm 5\%$, metal	74230-0590
R563	Res., 56 k, 1/4 W, $\pm 5\%$, metal	74230-0560
R564	Res., 20 k, 1/4 W, $\pm 5\%$, metal	74230-0310
R565	Res., 3.6 k, 1/4 W, $\pm 5\%$, metal	74230-1080
R566	Res., 51 k, 1/4 W, $\pm 5\%$, metal	74230-1010
R567	Same as R566	
R568	Res., 12 k, 1/4 W, $\pm 5\%$, metal	74230-0440
R569	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120
R570	Res., 15 k, 1/4 W, $\pm 5\%$, metal	74230-1170
R571	Same as R570	
R572	Res., 150, 1/4 W, $\pm 5\%$, compo.	74253-0580
D552	Diode, 1S 953	74040-1720
D554	Same as D552	
D560	Same as D552	
D561	Same as D552	
D562	Same as D552	
D563	Same as D552	
D564	Same as D552	
D565	Same as D552	
D566	Same as D552	
TR551	Transistor, 2N 4275	74030-3160
TR552	Transistor, 2N 4121	74030-2990
TR553	Same as TR552	
TR554	Same as TR552	
TR555	Same as TR552	
TR556	Same as TR552	
TR557	Transistor, 2SC 857 $\text{\textcircled{K}}$	74030-4280
NE564	Neon Lamp, NE-2	74020-1110
	Neon Lamp Socket	74480-1490

B TRIGGER GENERATOR

C601	Same as C301	
C602	Same as C302	
C603	Cap., 12 pF, 50 WVDC, $\pm 10\%$, cer.	74050-4450
C604	Same as C304	
C605	Same as C305	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C606	Same as C306	
C607	Same as C307	
C608	Same as C305	
C609	Same as C309	
C610	Same as C309	
C611	Same as C311	
C612	Same as C312	
C613	Same as C313	
C614	Same as C313	
C615	Same as C311	
C616	Same as C313	
C617	Same as C313	
C618	Same as C318	
C619	Same as C304	
C620	Same as C304	
C621	Same as C321	
C622	Same as C321	
C631	Same as C321	
C632	Same as C321	
C633	Same as C333	
C634	Same as C309	
C635	Same as C321	
C641	Same as C304	
C642	Same as C313	
C644	Same as C344	
L601	Same as L301	
L602	Same as L301	
L603	Same as L301	
L604	Same as L301	
L605	Same as L301	
L606	Same as L306	
L608	Same as L308	
L609	Same as L301	
L610	Same as L301	
R601	Same as R301	
R603	Same as R303	
R604	Same as R304	
R605	Same as R305	
R606	Same as R306	
R607	Same as R307	
R608	Same as R308	
R609	Same as R309	
R610	Same as R310	
R611a	Same as R311a	
R611b	Same as R351	
R612	Res., Var., 10 k, carbon	74322-1380
R613	Same as R313	
R614	Same as R314	
R615	Same as R315	
R616	Same as R316	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R617	Same as R317	
R618	Same as R318	
R619	Same as R319	
R620	Same as R320	
R621	Same as R321	
R622	Same as R321	
R623	Same as R323	
R624	Same as R323	
R625	Same as R325	
R626	Same as R325	
R627	Same as R325	
R628	Same as R325	
R629	Same as R329	
R630	Same as R330	
R631	Same as R330	
R632	Same as R332	
R633	Same as R332	
R634	Same as R334	
R635	Same as R334	
R636	Same as R336	
R637	Same as R336	
R638	Same as R317	
R639	Same as R317	
R640	Same as R340	
R641	Same as R341	
R642	Same as R342	
R643	Same as R342	
R644	Same as R323	
R645	Same as R340	
R646	Same as R323	
R647	Same as R340	
R648	Same as R348	
R650	Same as R350	
R651	Same as R351	
R652	Same as R314	
R653	Same as R353	
R654	Same as R354a	
R655	Same as R336	
R656	Same as R332	
R661	Same as R361	
R663	Same as R353	
R664	Same as R364	
R665	Same as R365	
R666	Same as R364	
R667	Same as R367	
R668	Same as R368	
R669	Same as R321	
R670	Same as R370	
R671	Same as R371	
R672	Same as R372	
R673	Same as R371	
R674	Same as R374	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R675	Same as R375	
R676	Same as R376b	
R677	Same as R392	
R678	Same as R361	
D601	Same as D301	
D602	Same as D302	
D603	Same as D301	
D604	Same as D301	
D605	Same as D301	
D606	Same as D301	
D607	Same as D301	
D608	Same as D301	
D609	Same as D301	
D610	Same as D301	
D611	Same as D311	
D612	Same as D312	
D613	Same as D312	
D614	Same as D311	
D616	Same as D301	
D617	Same as D317	
D618	Same as D301	
TR601a,b	Same as TR301a,b	
TR602	Same as TR302	
TR603	Same as TR302	
TR604	Same as TR304	
TR605	Same as TR304	
TR606	Same as TR306	
TR607	Same as TR306	
TR608	Same as TR302	
TR609	Same as TR302	
TR610	Same as TR304	
TR611	Same as TR304	
S601	Same as S301	
S602	Same as S302	
S603	Same as S303	
T601	Same as T301	
J601	Same as J301	

B SWEEP GENERATOR

C703	Cap., 0.001 μ F, 50 WVDC, +80 - -20 %, cer.	74060-1750
C710a	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580
C710b	Cap., 33 μ F, 10 WVDC, elect.	74120-3130
C711	Cap., 82 pF, 50 WVDC, $\pm$ 10 %, cer.	74050-4730

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C727	Cap., 47 pF, 50 WVDC, $\pm 10\%$, cer.	74050-2730	R725	Res., Var., 5 k, metal	74349-1650
C729	Cap., 39 pF, 50 WVDC, $\pm 10\%$, cer.	74050-3380	R726	Res., 100, 1/4 W, $\pm 5\%$, metal	74230-0130
C730	Cap., 10 pF, 50 WVDC, ± 1 pF, cer.	74050-1700	R727	Same as R722	
C734	Same as C710a		R728	Same as R723	
C738	Cap., 330 pF, 50 WVDC, $\pm 20\%$, cer.	74060-2620	R729	Res., 56, 1/4 W, $\pm 5\%$, metal	74230-0940
C740	Same as C703		R730	Same as R726	
C771a	Same as C730		R731	Res., 1.8 k, 1/4 W, $\pm 5\%$, metal	74230-0810
C771b	Same as C710a		R732	Same as R719	
C771c	Cap., 0.1 μ F, 25 WVDC, $\pm 80 - -20\%$, cer.	74060-1130	R733	Res., 5.1 k, 1/4 W, $\pm 5\%$, metal	74230-1020
C778	Same as C710a		R734	Same as R724	
C780	Same as C703		R735	Same as R722	
C781	Same as C703		R736a	Res., 75 k, 1 W, $\pm 2\%$, carbon	74242-0490
C782	Cap., 0.1 μ F, 25 WVDC, $\pm 80 - -20\%$, cer.	74060-2330	R736b	Res., 51, 1/4 W, $\pm 5\%$, metal	74230-0600
C783	Cap., 0.01 μ F, 500 WVDC, $\pm 100 - -0\%$, cer.	74060-0340	R736c	Res., 39, 1/4 W, $\pm 5\%$, metal	74230-1030
C784	Cap., 10 μ F, 100 WVDC, elect.	74120-0200	R737a	Res., 33 k, 1/4 W, $\pm 5\%$, metal	74230-0300
C785	Same as C710a		R737b	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120
C786	Same as C710a		R738	Same as R707c	
			R739	Res., 240, 1/4 W, $\pm 5\%$, metal	74230-1250
			R740A	Res., 200, 1/4 W, $\pm 5\%$, metal	74230-1340
			R740B	Same as R704	
			R741	Same as R726	
			R745	Res., 5.6 k, 1 W, $\pm 2\%$, carbon	74242-0460
L711	Inductor, Ferrite bead core	74560-1240	R746	Same as R726	
R701	Res., 1.5 k, 1/4 W, $\pm 5\%$, metal	74230-0110	R748a	Res., 15 k, 1/4 W, $\pm 5\%$, metal	74230-0140
R702	Res., Var., 1 k, metal	74349-1280	R748b	Res., 33, 1/4 W, $\pm 5\%$, metal	74230-0280
R703	Res., 220, 1/4 W, $\pm 5\%$, metal	74230-0480	R749	Res., 10, 1/4 W, $\pm 5\%$, metal	74230-0070
R704	Res., 4.7 k, 1/4 W, $\pm 5\%$, metal	74230-0290	R750	Same as R719	
R705	Res., 750, 1/4 W, $\pm 5\%$, metal	74230-0540	R751	Same as R719	
R706	Res., 910, 1/4 W, $\pm 5\%$, metal	74230-1260	R752	Res., 3.3 k, 1/4 W, $\pm 5\%$, metal	74230-0350
R707a	Res., 620, 1/2 W, $\pm 5\%$, metal	74230-1570	R753	Same as R739	
R707b	Res., 24, 1/4 W, $\pm 5\%$, metal	74230-1600	R754	Same as R706	
R707c	Res., 330, 1/4 W, $\pm 5\%$, metal	74230-0470	R755	Res., 1.6 k, 1/4 W, $\pm 5\%$, metal	74230-1320
R707d	Res., 75, 1/4 W, $\pm 5\%$, metal	74230-0880	R756	Res., Var., 1 k, W.W.	74331-0580
R707e	Res., 620, 1/4 W, $\pm 5\%$, metal	74230-1040	R757	Res., 470, 1/4 W, $\pm 5\%$, metal	74230-0160
R707f	Same as R705		R758	Res., 4.3 k, 1/4 W, $\pm 5\%$, metal	74230-1310
R709	Same as R704		R759a	Res., Var., 2 k, carbon	74349-0880
R710	Res., 33, 1/4 W, $\pm 5\%$, metal	74230-0280	R759b	Same as R703	
R711	Res., 3.3 k, 1/4 W, $\pm 5\%$, metal	74230-0350	R760	Same as R704	
R712	Same as R701		R762a	Res., 510, 1/4 W, $\pm 5\%$, metal	74230-0450
R713	Res., 11 k, 1/4 W, $\pm 5\%$, metal	74230-1550	R762b	Same as R706	
R714	Res., 43, 1/4 W, $\pm 5\%$, metal	74230-1220	R763	Same as R726	
R715	Same as R710		R765a	Same as R739	
R716	Res., 3.9 k, 1/2 W, $\pm 5\%$, metal	74230-1720	R765b	Same as R739	
R717	Res., 300, 1/4 W, $\pm 5\%$, metal	74230-1160	R766	Res., 2 k, 1/4 W, $\pm 5\%$, metal	74230-0410
R718	Res., 8.2 k, 1/4 W, $\pm 5\%$, metal	74230-0430	R767	Same as R766	
R719	Res., 47, 1/4 W, $\pm 5\%$, metal	74230-0100	R768	Res., Var., 2 k, W.W.	74331-0620
R720	Res., 30 k, 1/4 W, $\pm 5\%$, metal	74230-0920	R769	Res., Var., 2 k, W.W.	74341-0380
R721	Res., 3 k, 1/4 W, $\pm 5\%$, metal	74230-0530	R770	Same as R768	
R722	Res., 1 k, 1/4 W, $\pm 5\%$, metal	74230-0030	R771	Same as R719	
R723	Res., 12 k, 1/4 W, $\pm 5\%$, metal	74230-0440	R772	Res., 13 k, 2 W, $\pm 2\%$, carbon	74243-0550
R724	Res., 2.4 k, 1/4 W, $\pm 5\%$, metal	74230-0220	R773	Same as R719	
			R774	Res., 39, 1/4 W, $\pm 5\%$, metal	74230-1030

TIMING SWITCH B

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R851J	Same as R503J		C1022	Cap., Var., 6 – 20 pF, 250 WVDC, cer.	74110-0630
R851K	Same as R503K		C1023	Cap., 20 pF, 50 WVDC, $\pm 5\%$, cer.	74050-5280
R851L	Same as R503L		C1024	Same as C1022	
R851M	Same as R503M		C1025	Cap., 0.02 μ F, 50 WVDC, +80 – -20 %, cer.	74060-0660
R851N	Same as R503N		C1026	Cap., 10 pF, 500 WVDC, ± 1 pF, cer.	74050-1920
R861	Res., Var., 5 k, carbon (with S861)	74325-2320	C1027	Cap., Var., 0.5 – 4 pF, 500 WVDC, POLYPROPYLENE	74110-0300
R862	Same as R512		C1028	Same as C1027	
R863	Same as R513		C1029	Same as C1025	
R864	Same as R515		C1030	Same as C1026	
R865	Same as R514		C1031	Same as C1001a	
R866	Same as R516		C1032	Same as C1009	
R867	Same as R517		C1033	Same as C1001a	
R868	Same as R518				
R869	Same as R517				
TR861	Same as TR511		L1001	Inductor	74400-5030
TR862	Same as TR511		L1004	Inductor, Ferrite bead core	74560-1240
S851	Same as S501		L1006	Same as L1004	
S861	Reference R861		R1001	Res., Var., 500, carbon	74349-0630
HORIZ AMPLIFIER			R1002	Res., 510, 1/4 W, $\pm 5\%$, metal	74230-0450
C1001a	Cap., 0.01 μ F, 50 WVDC, +80 – -20 %, cer.	74060-0580	R1003	Res., 1.6 k, 1/4 W, $\pm 5\%$, metal	74230-1320
C1001b	Same as C1001a		R1004A	Res., 2.7 k, 1/4 W, $\pm 5\%$, metal	74230-0420
C1001c	Same as C1001a		R1004B	Res., 820, 1/4 W, $\pm 5\%$, metal	74230-0490
C1002	Cap., 4.7 μ F, 50 WVDC, elect.	74120-3260	R1005	Res., 1.1 k, 1/4 W, $\pm 5\%$, metal	74230-1530
C1003	Same as C1001a		R1006	Res., Var., 500, metal	74349-0760
C1004	Same as C1002		R1007	Same as R1003	
C1005	Cap., 0.01 μ F, 25 WVDC, +80 – -20 %, cer.	74060-0560	R1008	Res., 3.3 k, 1/4 W, $\pm 5\%$, metal	74230-0350
C1006	Cap., 4.7 μ F, 16 WVDC, elect.	74120-4480	R1010	Res., 6.8 k, 1/4 W, $\pm 5\%$, metal	74230-0330
C1007	Same as C1005		R1011	Res., 10 k, 1/4 W, $\pm 5\%$, metal	74230-0120
D1008	Same as C1006		R1012	Same as R1005	
C1009	Cap., 0.0022 μ F, 500 WVDC, +100 – -0, cer.	74060-0840	R1013	Same as R1010	
C1010	Cap., 4.7 μ F, 100 WVDC, elect.	74120-4580	R1015	Res., 51, 1/4 W, $\pm 5\%$, metal	74230-0600
C1011	Same as C1009		R1016	Res., 13 k, 1/4 W, $\pm 5\%$, metal	74230-1390
C1012	Cap., 4.7 μ F, 160 WVDC, elect.	74120-1830	R1017	Res., 7.5 k, 1/4 W, $\pm 5\%$, metal	74230-0570
C1013	Same as C1009		R1018	Res., 120 k, 1/4 W, $\pm 5\%$, compo.	74253-1310
C1014	Cap., 3.3 μ F, 250 WVDC, elect.	74120-3310	R1019	Same as R1005	
C1015	Cap., 75 pF, 50 WVDC, $\pm 5\%$, cer.	74050-5910	R1020	Res., 2.2 k, 1/4 W, $\pm 5\%$, metal	74230-0270
C1016	Cap., 15 pF, 50 WVDC, $\pm 10\%$, cer.	74050-1730	R1021	Res., 22 k, 1/4 W, $\pm 5\%$, metal	74230-0320
C1018	Same as C1001a		R1022	Same as R1020	
C1019	Cap., 0.1 μ F, 25 WVDC, +80 – -20 %, cer.	74060-2330	R1023	Res., 15 k, 1/4 W, $\pm 5\%$, metal	74230-0140
C1020	Same as C1005		R1024	Same as R1020	
C1021	Cap., Var., 0.5 – 1.5 pF, Fluorine Resin	74110-0290	R1025	Same as R1020	
			R1026	Res., Var., 1 k, carbon	74349-0640
			R1027	Res., 1.3 k, 1/4 W, $\pm 5\%$, metal	74230-1330
			R1028	Res., 12 k, 1/2 W, $\pm 2\%$, carbon	74241-0670
			R1029	Res., 220, 1/4 W, $\pm 5\%$, metal	74230-0480
			R1030	Res., Var., 100, metal	74349-0900
			R1031	Same as R1028	
			R1032	Res., 100, 1/4 W, $\pm 5\%$, metal	74230-0130
			R1033	Res., 1.5 k, 1/2 W, $\pm 2\%$, carbon	74241-0460

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R1034	Same as R1033		D1014	Same as D1008	
R1035	Same as R1032		D1015	Diode, 1S 955	74040-1840
R1036	Res., 33, 1/4 W, $\pm 5\%$, metal	74230-0280	D1016	Same as D1015	
R1037	Same as R1036		D1017	Z. Diode, HW 10A	74040-4110
R1038	Res., 240, 1/4 W, $\pm 5\%$, metal	74230-1250	D1018	Same as D1012	
R1039	Res., 1 k, 2 W, $\pm 2\%$, carbon	74243-0350	D1019	Same as D1008	
R1040	Same as R1001		D1021	Same as D1015	
R1041	Same as R1029		D1022	Same as D1015	
R1042	Res., 120, 1/4 W, $\pm 5\%$, metal	74230-1130	D1023	Same as D1017	
R1043	Res., 1.2 k, 1/2 W, $\pm 2\%$, carbon	74241-0450	D1024	Same as D1003	
R1044	Res., 3 k, 1 W, $\pm 2\%$, carbon	74242-0390			
R1045	Res., 2.2 k, 1 W, $\pm 2\%$, carbon	74242-0360	TR1001	Transistor, 2N 4275	74030-3160
R1046	Same as R1036		TR1002	Transistor, 2N 4258	74030-3150
R1047	Res., 3 k, 1/4 W, $\pm 5\%$, metal	74230-0530	TR1003	Same as TR1002	
R1048	Res., 3 k, 1/6 W, $\pm 5\%$, metal	74230-1690	TR1004	Transistor, 2N4121	74030-2990
R1049	Same as R1048		TR1005	Same as TR1004	
R1050	Same as R1048		TR1006	Same as TR1004	
R1051	Res., 680, 1/2 W, $\pm 2\%$, carbon	74241-0400	TR1007	Same as TR1004	
R1052	Res., 2.4 k, 1/2 W, $\pm 2\%$, carbon	74241-0510	TR1008	Transistor, 2N 5109	74030-4610
R1053	Res., 1.6 k, 1/2 W, $\pm 2\%$, carbon	74241-0470		Radiator, TXBF-032-025B	74030-3050
R1054	Same as R1051		TR1009	Same as TR1008	
R1055	Same as R1048		TR1010	Same as TR1004	
R1056	Same as R1048		TR1011	Same as TR1001	
R1057	Same as R1048		TR1012	Same as TR1001	
R1058	Res., 2 k, 1/4 W, $\pm 5\%$, metal	74230-0410	TR1013	Same as TR1001	
R1059	Res., 24, 1/4 W, $\pm 5\%$, metal	74230-1600	TR1015	Transistor, 2N 3637	74030-4640
R1060	Same as R1059			Radiator, 1G-46020	74030-1960
R1062	Res., 4.7, 1/8 W, $\pm 5\%$, compo.	74257-0990	TR1017	Transistor, 2N 3500	74030-3210
R1063	Res., 160 k, 1/2 W, $\pm 2\%$, carbon	74241-0940		Radiator, 1G-46020	74030-1960
R1064	Res., 2 k, 10 W, $\pm 5\%$, No-inductive W.W.	74220-0130			
R1065	Same as R1064		NE1001	Neon Lamp, NE68	74020-1170
R1066	Same as R1063			Neon Lamp Socket	74480-1490
R1068	Same as R1062		NE1002	Same as NE1001	
R1069	Res., 6.8 k, 1/2 W, $\pm 2\%$, carbon	74241-0620	RL1001	Relay, MR0113	74450-1190
R1070a-b (with S1070)	Res., Var., 10 k + 10 k, carbon	74325-2710	RL1002	Same as RL1001	
R1071	Same as R1023		S1070	Reference R1070a-b	
D1001	Diode, 1S 1458	74040-2920			
D1002	Same as D1001		J1001	Connector (For Printed Circuit Board used)	74500-1070
D1003	Diode, 1S 953	74040-1720			
D1004	Z. Diode, 1S 992	74040-2660			
D1005	Same as D1003				
D1006	Same as D1004				
D1007	Same as D1003				
D1008	Z. Diode, HW 20B	74040-3400			
D1009	Same as D1008				
D1010	Same as D1008				
D1011	Same as D1008				
D1012	Z. Diode, RD 5A	74040-0770			
D1013	Same as D1008				

Z AMPLIFIER

C1100	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580
C1101	Cap., 0.001 μ F, 50 WVDC, $\pm 5\%$, cer.	74050-1750
C1102	Cap., Var., 6 - -20 pF, 250 WVDC, cer.	74110-0630

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C1103	Cap., 0.0022 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0840	R1133	Same as R1103	
C1105	Cap., Var., 0.5 - 1.5 pF,	74110-0290	R1134	Same as R1103	
C1106	Cap., 180 pF, 50 WVDC, $\pm$ 10 %, cer.	74050-5950	R1135	Same as R1105	
C1107	Cap., 0.01 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0730	R1136	Res., 2.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0270
C1109	Same as C1107		R1140	Res., Var., 5 k, metal	74349-1670
C1110	Same as C1100		D1100	Diode, 1S 1458	74040-0920
C1111	Cap., 0.01 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0560	D1101	Same as D1100	
C1112a	Same as C1111		D1102	Z. Diode, RD16A	74040-0920
C1112b	Same as C1100		TR1100	Transistor, 2N 4275	74030-3160
C1125	Cap., 10 pF, 500 WVDC, $\pm$ 2 pF, cer.	74050-5440	TR1101	Same as TR1100	
C1126	Same as C1125		TR1102	Same as TR1100	
C1127	Same as C1125		TR1103	Same as TR1100	
C1130	Same as C1111		TR1104	Transistor, 2N 4121	74030-2990
R1100	Res., 56, 1/4 W, $\pm$ 5 %, metal	74230-0940	TR1105	Same as TR1100	
R1101	Res., 100, 1/4 W, $\pm$ 5 %, metal	74230-0130	TR1106	Transistor, 2SA 565B	74030-3910
R1102	Res., 4.3 k, 1/4 W, $\pm$ 5 %, metal	74230-1310		Radiator, NZ 1C	74030-3920
R1103	Res., 10, 1/4 W, $\pm$ 5 %, metal	74230-0070	TR1107	Same as TR1106	
R1104a	Res., 750, 1/4 W, $\pm$ 5 %, metal	74230-0540	TR1108	Same as TR1106	
R1104b	Res., 200, 1/4 W, $\pm$ 5 %, metal	74230-1340	TR1109	Same as TR1106	
R1105	Res., 6.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0890	TR1110	Same as TR1106	
R1106	Res., Var., 500, carbon	74349-0630	TR1111	Transistor, 2SC 154C	74030-4000
R1107	Res., 910, 1/4 W, $\pm$ 5 %, metal	74230-1260		Radiator, QQB-6	74030-3900
R1108	Res., 1 k, 1/4 W, $\pm$ 5 %, metal	74230-0030	J1100	Transformer	74400-4780
R1109	Res., 47, 1/4 W, $\pm$ 5 %, metal	74230-0100	J1101	Connector, UG625/U-Ni, BNC receptacle	74500-2530
R1110	Res., 15 k, 1/4 W, $\pm$ 5 %, metal	74230-0140	J1102	Connector (For Printed Circuit board use)	74500-1070
R1111	Res., 910, 1/4 W, $\pm$ 5 %, metal	74230-1260	CRT CIRCUIT		
R1112	Res., 10 k, 1/4 W, $\pm$ 5 %, metal	74230-0120	C1201	Cap., 47 μ F, 50 WVDC, elect.	74120-3270
R1113	Res., 4.3 k, 1/4 W, $\pm$ 5 %, metal	74230-0090	C1202	Cap., 0.1 μ F, 50 WVDC, $\pm$ 10 %, poly.	74130-2470
R1114	Same as R1108		C1203	Cap., 0.02 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0570
R1115	Res., 6.8 k, 1/2 W, $\pm$ 2 %, carbon	74241-0620	C1204	Same as C1202	
R1116	Same as R1115		C1205	Cap., 0.001 μ F, 3 k WVDC, +100 - -0 %, cer.	74060-2740
R1117	Same as R1103		C1206	Cap., 0.001 μ F, 3 k WVDC, +80 - -20 %, cer.	74060-2760
R1118	Same as R1101		C1207	Same as C1206	
R1119	Res., 2 k, 1/4 W, $\pm$ 5 %, metal	74230-0410	C1208	Cap., 4.7 μ F, 160 WVDC, elect.	74120-1830
R1121	Res., 6.2 k, 1/4 W, $\pm$ 5 %, metal	74230-0890	C1209	Same as C1206	
R1122	Res., 100 k, 1/4 W, $\pm$ 5 %, metal	74230-0260	C1210	Same as C1206	
R1123	Res., 620, 1/4 W, $\pm$ 5 %, metal	74230-1040	C1221	Cap., 0.001 μ F, 7 k WVDC, +80 - -20 %, cer.	74060-2630
R1124	Same as R1103		C1222	Same as C1221	
R1125	Res., 20 k, 1/4 W, $\pm$ 5 %, metal	74230-0310	C1223	Same as C1221	
R1126	Same as R1125		C1224	Same as C1221	
R1127	Same as R1125				
R1128	Same as R1125				
R1129	Same as R1125				
R1130	Same as R1103				
R1131	Same as R1103				
R1132	Same as R1103				

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C1225	Cap., 250 pF, 20 k WVDC, +100 - 0 %, cer.	74060-2730
C1261	Cap., 0.001 μ F, 500 WVDC, +100 - 0 %, cer.	74060-0700
C1262	Cap., 0.005 μ F, 3 k WVDC, +100 - 0 %, cer.	74060-2010
C1263	Same as C1262	
C1264	Cap., 100 pF, 500 WVDC, $\pm$ 10 %, cer.	74050-1930
C1265	Same as C1262	
C1266	Same as C1261	
L1201	Inductor	74470-1810
R1201	Res., Var., 100 k, carbon	74349-0650
R1202	Res., 2 M, 1/2 W, $\pm$ 5 %, compo.	74254-0590
R1203	Res., 10 k, 1/4 W, $\pm$ 5 %, metal	74230-0120
R1204	Res., 10, 1/4 W, $\pm$ 5 %, metal	74230-0070
R1205	Res., 100 k, 1/4 W, $\pm$ 5 %, metal	74230-0260
R1206	Res., 1.2 M, 1/2 W, $\pm$ 5 %, compo.	74254-0650
R1207	Res., 35 M, 2 W, $\pm$ 10 %,	74256-0130
R1208	Same as R1207	
R1209	Res., 2 M, 1/2 W, $\pm$ 5 %, compo.	74254-0080
R1210	Res., 33 k, 1/4 W, $\pm$ 5 %, metal	74230-0300
R1211	Res., Var., 100 k, carbon	74349-0890
R1212	Res., 47 k, 1/4 W, $\pm$ 5 %, metal	74230-0170
R1221	Same as R1206	
R1231	Res., Var., 200 k, metal	74349-2350
R1232	Same as R1231	
R1233	Same as R1210	
R1234	Same as R1231	
R1235	Res., 2M, 1/2 W, $\pm$ 5 %, compo.	74254-0590
R1236	Res., Var., 2 M, metal	74349-1560
R1237	Res., 22 M, 2 W, $\pm$ 10 %	74256-0120
R1238	Same as R1236	
R1239	Same as R1202	74322-2220
R1240	Res., Var., 4 M, carbon	74322-2220
R1241	Res., Var., 4 M, carbon	74322-0770
R1242	Res., 17 M, 2 W, $\pm$ 10 %	74256-0090
R1243	Same as R1231	
R1244	Same as R1231	
R1251	Res., Var., 1 k, W.W.	74331-0740
R1252	Same as R1251	
R1253	Res., 360, 1/2 W, $\pm$ 2 %, carbon	74241-0330
R1254	Same as R1253	
R1255	Res., Var., 2 k, W.W.	74331-0430
R1261	Res., 30 k, 1/4 W, $\pm$ 5 %, metal	74230-0920
R1262	Res., 3 M, 1/2 W, $\pm$ 5 %, compo.	74254-0640
R1263	Res., 470, 1/4 W, $\pm$ 5 %, metal	74230-0160
R1264	Res., 100, 1/4 W, $\pm$ 5 %, metal	74230-0130
R1265	Same as R1205	
R1266	Res., 22 k, 1/4 W, $\pm$ 5 %, metal	74230-0320

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R1267	Res., 110 k, 1/4 W, $\pm$ 5 %, compo.	74253-1300
D1201	Diode, HF SD-1	74040-3140
D1202	Rectifier, VF5-12X	74040-3560
D1203	Same as D1202	
D1221	Same as D1202	
D1222	Same as D1202	
D1223	Same as D1202	
D1224	Same as D1202	
D1231	Z. Diode, RD 16A	74040-0920
TR1201	Transistor, 2SD 93	74030-3760
IC1201	Integrated Circuit, A2	74570-0020
J1201	Connector (For Printed Circuit board use)	74500-3570
F1201	Fuse, 1 A, Slow blow	74540-0420
	Fuse Holder	74480-1880
NE1201	Neon Lamp, NE-2	74020-1110
NE1202	Same as NE1201	
NE1203	Same as NE1201	
T1201	Transformer	74471-0950
V1201	Cathode Ray Tube, D13-500GH/01	74010-1120
	Anode Cap	74480-0220

POWER SUPPLY (I) & (II)

C1301	Cap., 47 μ F, 16 WVDC, elect.	74120-3090
C1302	Cap., 0.01 μ F, 50 WVDC, +80 - 20 %, cer.	74060-0580
C1303	Cap., 2200 μ F, 25 WVDC, elect.	74120-3760
C1304	Cap., 10 μ F, 10 WVDC, elect.	74120-0320
C1321	Same as C1301	
C1322	Same as C1304	
C1323	Same as C1302	
C1324	Same as C1303	
C1325	Cap., 220 μ F, 16 WVDC, elect.	74120-1020
C1341	Cap., 10 μ F, 50 WVDC, elect.	74120-0980
C1342	Cap., 0.001 μ F, 25 WVDC, +80 - 20 %, cer.	74060-0550
C1343	Same as C1302	
C1344	Cap., 470 μ F, 80 WVDC, elect.	74120-4560
C1345	Cap., 2.2 μ F, 350 WVDC, elect.	74120-4230
C1346	Cap., 1 μ F, 110 WVAC, Metallic Paper	74080-1170
C1361	Cap., 47 μ F, 50 WVDC, elect.	74120-2970

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C1362	Cap., 470 μ F, 100 WVDC, elect.	74120-2950	R1345	Res., 820, 1/4 W, $\pm$ 5 %, metal	74030-0490
C1363	Cap., 0.001 μ F, 500 WVDC, +100 - 0 %, cer.	74060-0340	R1346	Res., 5.68 k, 1/4 W, $\pm$ 1 %, metal	74221-1410
C1364	Cap., 10 μ F, 160 WVDC, elect.	74120-1050	R1347	Res., 16 k, 1/4 W, $\pm$ 5 %, metal	74230-1510
C1365	Cap., 2.2 μ F, 150 WVDC, elect. tan.	74120-2110	R1348	Res., 47 k, 1/2 W, $\pm$ 2 %, carbon	74241-0810
C1366	Cap., 0.001 μ F, 500 WVDC, +100 - 0 %, cer.	74060-0700	R1349	Res., 15 k, 1/2 W, $\pm$ 2 %, carbon	74241-0690
C1367	Same as R1366		R1350	Res., 100 k, 1/4 W, $\pm$ 5 %, metal	74230-0260
C1368	Same as R1366		R1361	Res., 1.8 k, 1/2 W, $\pm$ 2 %, carbon	74241-0580
C1381ab	Cap., 680 μ F + 330 μ F, 100 WVDC, elect.	74120-2960	R1362	Same as R1347	
C1382	Same as R1366		R1363	Same as R1343	
C1383	Cap., 4.7 μ F, 75 WVDC, elect. tan.	74120-2990	R1364	Same as R1302	
C1384	Cap., 22 μ F, 160 WVDC, elect.	74120-2570	R1365	Res., 200, 1/4 W, $\pm$ 5 %, metal	74230-1340
C1401	Cap., 33 μ F, 50 WVDC, elect.	74120-4460	R1366	Res., 100, 1/4 W, $\pm$ 5 %, metal	74230-0130
C1402	Same as C1302		R1367	Res., 38.3 k, 1/2 W, $\pm$ 1 %, metal	74221-1440
C1421	Cap., 1 μ F, 350 WVDC, elect.	74120-2980	R1368	Res., 3.72 k, 1/4 W, $\pm$ 1 %, metal	74221-1380
C1431	Cap., 0.0047 μ F, 500 WVDC, +100 - 0 %, cer.	74060-0770	R1369	Res., 100 k, 1/2 W, $\pm$ 2 %, carbon	74241-0890
C1432	Same as C1364		R1370	Res., 10, 2 W, $\pm$ 5 %, W.W.	74220-0270
C1433	Same as C1366		R1381	Same as R1369	
C1434	Cap., 0.01 μ F, 500 WVDC, +100 - 0 %, cer.	74060-0730	R1382	Res., 100, 7 W, $\pm$ 5 %, W.W.	74291-1080
C1440	Same as C1366		R1383	Same as R1382	
C1451	Same as C1342		R1384	Same as R1365	
C1452	Same as C1401		R1385	Same as R1302	
R1301	Res., 33, 7 W, $\pm$ 5 %, W.W.	74291-1060	R1386	Res., 1.2, 2 W, $\pm$ 5 %, W.W.	74220-0240
R1302	Res., 220, 1/4 W, $\pm$ 5 %, metal	74230-0480	R1387a	Res., 16.2 k, 1/4 W, $\pm$ 1 %, metal	74221-1420
R1303	Res., 0.3, 2 W, $\pm$ 5 %, W.W.	74220-0230	R1387b	Same as R1350	
R1304	Res., 150, 1/4 W, $\pm$ 5 %, metal	74230-0510	R1388	Res., Var., 500, W.W.	74331-0360
R1305	Res., 1 k, 1/4 W, $\pm$ 1 %, metal	74221-1300	R1389	Same as R1368	
R1306	Res., Var., 200, W.W.	74331-0680	R1390	Res., 33 k, 1/4 W, $\pm$ 5 %, metal	74230-0300
R1307	Same as R1305		R1392	Same as R1370	
R1308	Res., 4.3 k, 1/4 W, $\pm$ 5 %, metal	74230-1310	R1401	Same as R1302	
R1309	Same as R1305		R1402	Same as R1343	
R1310	Res., 3.01 k, 1/4 W, $\pm$ 1 %, metal	74221-1350	R1403	Res., 39, 1/4 W, $\pm$ 5 %, metal	74230-0780
R1311	Res., 10 k, 1/2 W, $\pm$ 2 %, carbon	74241-0660	R1404	Res., 330, 1/4 W, $\pm$ 5 %, metal	74230-0470
R1320	Res., 47, 7 W, $\pm$ 5 %, metal	74291-1070	R1405	Res., 11 k, 1/4 W, $\pm$ 5 %, metal	74230-1550
R1321	Res., 47, 7 W, $\pm$ 5 %, W.W.	74291-1070	R1406	Res., 3.16 k, 1/4 W, $\pm$ 1 %, metal	74221-1360
R1322	Same as R1304		R1407	Same as R1388	
R1323	Res., 1.1 k, 1/4 W, $\pm$ 1 %, metal	74221-1310	R1408	Res., 2.67 k, 1/4 W, $\pm$ 1 %, metal	74221-1340
R1324	Same as R1306		R1409	Res., Var., 50, W.W.	74331-0640
R1325	Res., 392, 1/4 W, $\pm$ 1 %, metal	74221-1430	R1410	Res., 150 k, 1/2 W, $\pm$ 2 %, carbon	74241-0930
R1326	Res., 2 k, 1/4 W, $\pm$ 5 %, metal	74230-0410	R1411	Same as R1349	
R1327	Same as R1302		R1421	Same as R1403	
R1328	Same as R1303		R1422	Res., 75 k, 1/4 W, $\pm$ 5 %, metal	74230-0590
R1329	Same as R1311		R1423	Res., Var., 20 k, metal	74349-1530
R1341	Same as R1302		R1424	Res., 91 k, 1/4 W, $\pm$ 5 %, metal	74230-1000
R1342	Same as R1302		R1431	Same as R1345	
R1343	Res., 2, 2 W, $\pm$ 5 %, W.W.	74220-0250	R1432	Res., 24, 2 W, $\pm$ 5 %, W.W.	74220-0260
R1344	Res., 2.43 k, 1/4 W, $\pm$ 1 %, metal	74221-1320	R1433	Res., 12 k, 1 W, $\pm$ 2 %, carbon	74242-0540
			R1434	Res., 68 k, 1/4 W, $\pm$ 5 %, metal	74230-0010
			R1435	Res., 1 M, 1/2 W, $\pm$ 2 %, metal	74241-1130
			R1436	Res., 5.1 k, 1/4 W, $\pm$ 5 %, metal	74230-1020
			R1437	Res., 160, 1/4 W, $\pm$ 5 %, metal	74230-1410
			R1438	Res., 39, 2 k, 1/2 W, $\pm$ 1 %, metal	74221-1450
			R1439	Same as R1388	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R1440	Res., 4.12 k, 1/4 W, $\pm 1\%$, metal	74221-1390	TR1302	Transistor, 2SD 221	74030-4010
R1441	Same as R1365		TR1321	Same as TR1301	
R1452	Res., 15 k, 1/4 W, $\pm 5\%$, metal	74230-0140	TR1322	Same as TR1302	
R1453	Same as R1302		TR1341	Transistor, 2SC 1030B	74030-4920
R1454	Res., 4.99 k, 1/4 W, $\pm 1\%$, metal	74221-1400	TR1342	Same as TR1302	
R1455	Same as R1388		TR1361	Transistor, 2SC 558	74030-5150
R1456	Res., 2.46 k, 1/4 W, $\pm 1\%$, metal	74221-1330	TR1362	Transistor, 2SC 154C	74030-4000
R1551	Res., 20 k, 1/4 W, $\pm 5\%$, metal	74230-0310	TR1363	Transistor, 2SC 321 H B	74030-4500
D1301	Diode, 1S 953	74040-1720	TR1364	Same as TR1362	
D1302a	Rectifier, VO 3C	74040-3350	TR1381	Same as TR1341	
D1302b	Same as D1302a		TR1382	Same as TR1302	
D1302c	Same as D1302a		TR1383	Same as TR1363	
D1302d	Same as D1302a		TR1384	Transistor, 2SC 650 B	74030-2310
D1321	Z. Diode, 1S 552	74040-3220	TR1401	Transistor, 2SD 224	74030-5110
D1322a	Same as D1302a		TR1421	Same as TR1362	
D1322b	Same as D1302a		TR1431	Transistor, 2SA 604	74030-4300
D1322c	Same as D1302a		TR1432	Same as TR1362	
D1322d	Same as D1302a		TR1433	Same as TR1362	
D1323	Rectifier, M4C-1	74040-3880	TR1435	Same as TR1361	
D1341	Same as D1301		TR1451	Transistor, 2N 4121	74030-2990
D1342	Same as D1323		TR1452	Same as TR1451	
D1343	Rectifier, VO 6G-1	74040-4010	TR1453	Same as TR1401	
D1361	Same as D1323		IC1301	Integrated Circuit, A1	74030-4700
D1362	Diode, HW 20B	74040-3400	IC1321	Same as IC1301	
D1363	Z. Diode, HW 20B	74040-3400	IC1341	Same as IC1301	
D1364	Same as D1302a		IC1401	Same as IC1301	
D1365	Z. Diode, HW 75A	74040-2880	S1341	Thermal cut out	74450-1170
D1366	Same as D1301		S1342	Switch, Toggle	74430-0350
D1367	Same as D1301		S1343	Switch, Toggle	74430-0370
D1368	Same as D1301		J1301	Connector (For printed circuit board used)	74500-3560
D1369	Same as D1343		J1302	Connector (For printed circuit board used)	74500-1070
D1370	Same as D1302a		J1303	Connector (For printed circuit board used)	74500-1900
D1381	Same as D1343		F1341	Fuse, 0.5 A	74540-0260
D1382	Same as D1301		F1342	Fuse, 3A, slow blow	74540-0500
D1383	Z. Diode, HW 30B	74040-3480	F1361	Fuse, 0.25 A	74540-0270
D1384	Same as D1301		F1381	Same as F1341	
D1385	Same as D1301		F1401	Same as F1341	
D1401	Same as D1302a			Fuse Holder (For F1342)	74480-0950
D1402	Same as D1301			Fuse Holder (For F1341, F1361, F1381, F1401)	74480-1880
D1403	Same as D1301		NE1341	Neon Lamp bracket, BNF-3	74020-1770
D1421	Diode, HF SD-1	74040-3140	T1301	Transformer	74471-2290
D1431	Z. Diode, RD5A	74040-0770	PL1401	Illumination lamp, 6.3 V 150 mA	74490-0150
D1432	Same as D1431				
D1433	Z. Diode, HW 16A	74040-3060			
D1434	Same as D1365				
D1435	Same as D1301				
D1436	Same as D1301				
D1437	Same as D1301				
D1451	Same as D1301				
D1452	Same as D1301				
TR1301	Transistor, 2SD 163	74030-5100			

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
PL1402	Same as PL1401	
FAN MOTOR		74550-0200

CALIBRATOR

L1514	Inductor, Ferrite bead core	74560-1240
L1515	Same as L1514	
C1501	Cap., 0.1 μ F, 50 WVDC, +0 - -2 %, poly.	74130-1770
C1502	Cap., 0.047 μ F, 50 WVDC $\pm$ 10 %, poly.	74130-0940
C1503	Cap., 22 μ F, 16 WVDC, elect.	74120-0230
C1504	Same as C1503	
C1505	Cap., 470 pF, 500 WVDC, +100 - -0 %, cer.	74060-2540
C1506	Cap., 0.1 μ F, 25 WVDC, +80 - -20 %, cer.	74060-2330
C1515	Cap., 0.01 μ F, 50 WVDC, +80 - -20 %, cer.	74060-0580
R1501	Res., 10 k, 1/4 W, $\pm$ 5 %, metal	74230-0120
R1502	Res., 10, 1/4 W, $\pm$ 5 %, metal	74230-0070
R1503	Res., Var., 500 Ω , metal	74349-1570
R1504	Res., 1.6 k, 1/4 W, $\pm$ 5 %, metal	74230-1320
R1505	Res., 47, 1/4 W, $\pm$ 5 %, metal	74230-0100
R1506	Res., 2 k, 1/4 W, $\pm$ 0.5 %, metal	74221-1540
R1507	Res., 1 k, 1/4 W, $\pm$ 0.5 %, metal	74221-1530
R1508	Res., 667, 1/4 W, $\pm$ 0.5 %, metal	74221-1520
R1509	Res., 179, 1/4 W, $\pm$ 0.5 %, metal	74221-1510
R1510	Res., 80.1, 1/4 W, $\pm$ 0.5 %, metal	74221-1500
R1511	Res., 45.2, 1/4 W, $\pm$ 0.5 %, metal	74221-1480
R1512	Res., 28.7, 1/4 W, $\pm$ 0.5 %, metal	74221-1470
R1513	Res., 5 k, 1/4 W, $\pm$ 0.5 %, metal	74221-1550
R1514	Res., 21.3, 1/4 W, $\pm$ 0.5 %, metal	74221-1460
R1515	Same as R1513	
R1516	Res., 50, 1/4 W, $\pm$ 0.5 %, metal	74221-1490

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R1517	Res., 0.25, 0.5 W, $\pm$ 20 %, W.W.	74310-1180
R1518	Res., 9.1 k, 1/4 W, $\pm$ 5 %, metal	74230-1090
TR1501	Transistor, 2SC 321 H B	74030-4500
IC1501	Integrated circuit, LG 632	74030-4690
S1501	Switch, Rotary	74431-5320
T1501	Transformer	74472-0830
J1501	Connector, BNC-RBP2-14, BNC, BNC receptacle	74500-2480

INTER CONNECTING

C1601	Cap., 0.01 μ F, 25 WVDC, +80 - -20 %, cer.	74060-0580
C1602	Same as C1601	
C1603	Cap., 0.01 μ F, 500 WVDC, +100 - -0 %, cer.	74060-0340
C1604	Same as C1601	
C1605	Same as C1603	
C1606	Same as C1601	
L1602	Inductor, Ferrite bead core	74560-1240
L1603	Same as L1602	
L1604	Same as L1602	
R1601	Res., 51, 1/4 W, $\pm$ 5 %, metal	74230-0600
J1601	Connector, 24 Pin	74500-0440
J1602	Connector, 36 Pin	74500-0500
J1603	Connector, BNC-RBP2-14, BNC receptacle	74500-2480
J1604	Connector, UG625/U-Ni, BNC receptacle	74500-2530
J1605	Same as J1604	

notes

Abbreviations used in this manual are as follows:

◆ For units:

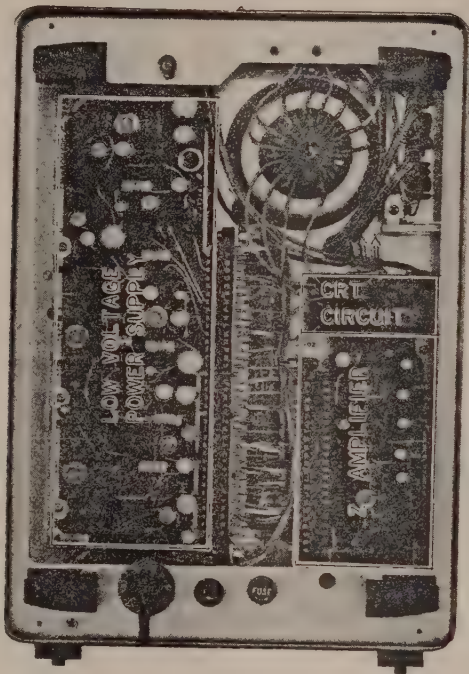
A	ampere
mA	milliampere
μ A	microampere
nA	nanoampere(10^{-9} A)
dB	decibel
div(DIV)	division
g	gram
kg	kilogram
Hz	hertz
kHz	kilohertz
MHz	megahertz
GHz	gigahertz
m	meter
cm	centimeter
mm	millimeter
sec(SEC)	second
msec	millisecond
μ sec	microsecond
nsec	nanosecond(10^{-9} sec)
psec	picosecond(10^{-12} sec)
F	farad
μ F	microfarad
pF	picofarad
V	volt
mV	millivolt
μ V	microvolt
VA	voltampere
W	watt
mW	milliwatt
Ω	ohm
M Ω	megaohm
k Ω	kilohm
rms	root mean square
p-p	peak to peak

◆ Others:

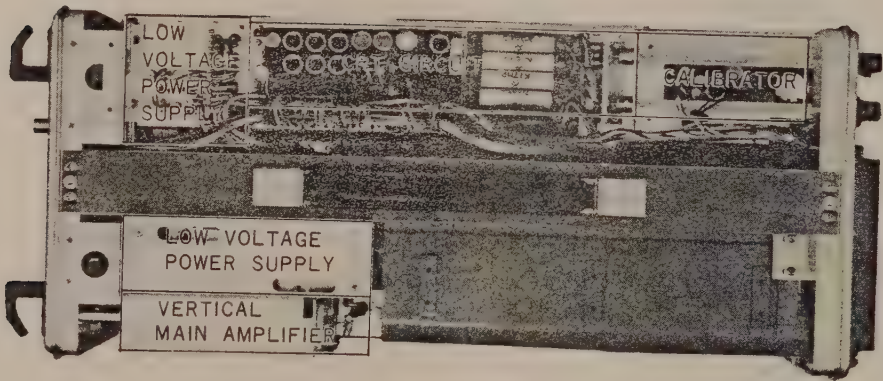
AC	alternate current
ADJ	adjust
ALT	alternate
ASTIG	astigmatism
AUTO(Auto)	automatic
BAL	balance
CALIB	calibrated
CAL OUT	calibrator output
CENT	center
CH 1	channel 1
CH 2	channel 2
CHOP	chopped
DC	direct current
EXT	external
GND	ground(earth)
HF REJ	high frequency reject
HORIZ	horizontal
ILLUM	illumination
INT	internal
INTEN	intensity
LF REJ	low frequency reject
MAG	magnifier
NORM	normal
SENS	sensitivity
SWP	sweep
TRIG	trigger
UNCAL	uncalibrated
VERT	vertical

Circuit Arrangement Diagrams

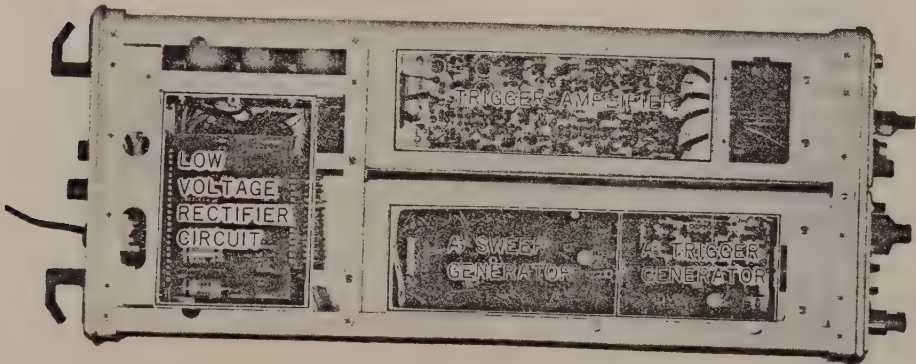
Rear Panel



Top View

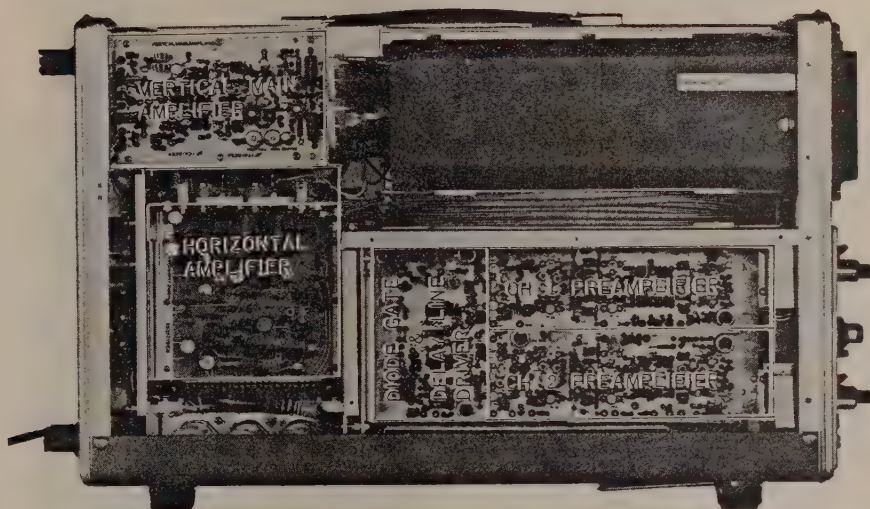


Bottom View

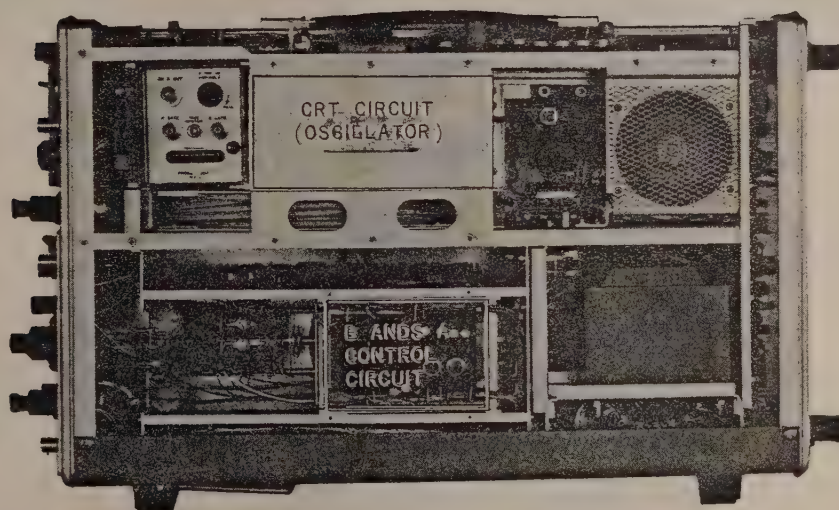


Circuit Arrangement Diagrams

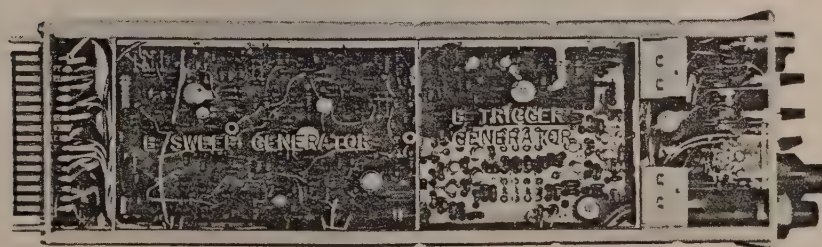
Left Side Panel



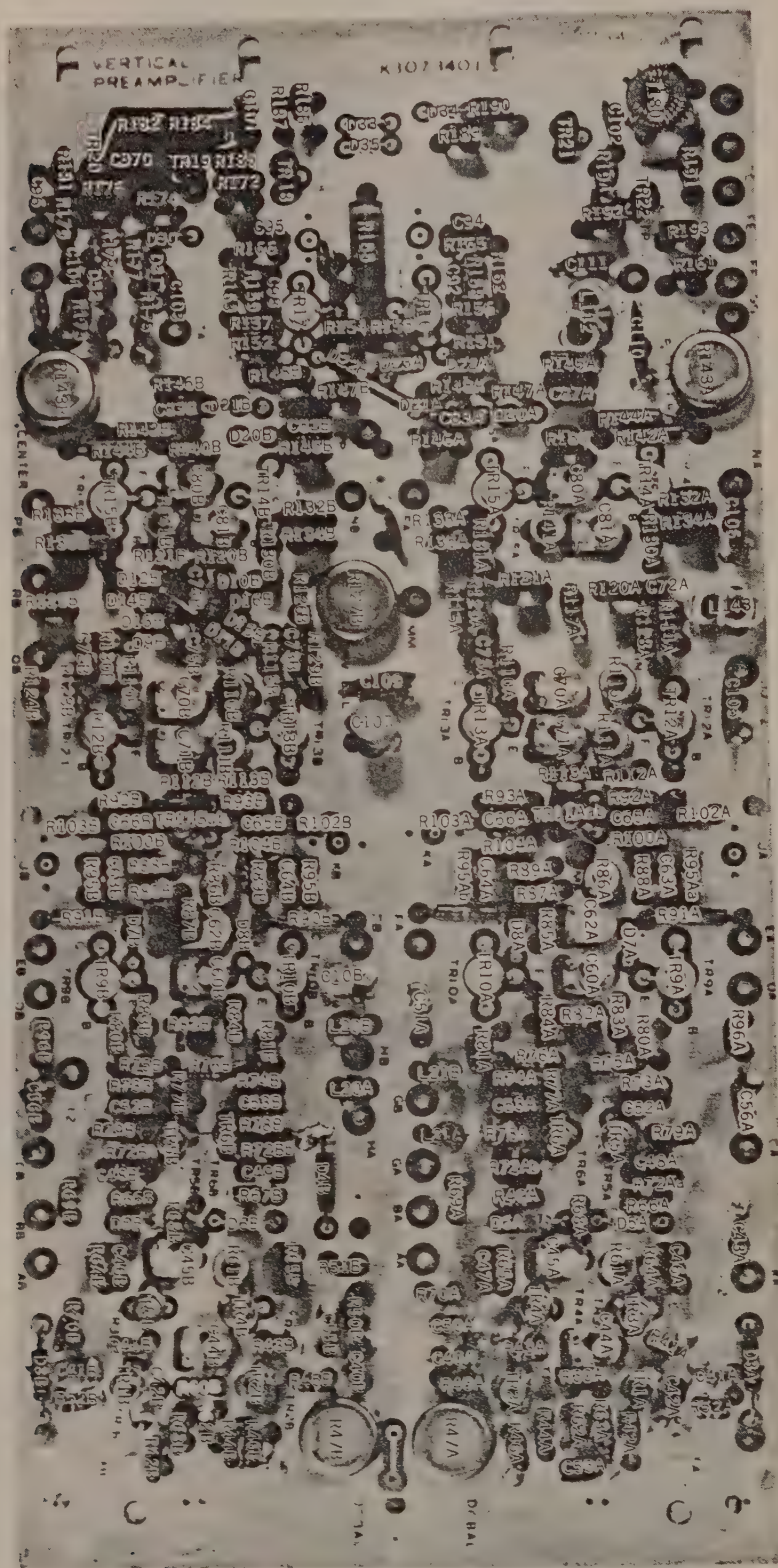
Right Side Panel



Horizontal Plug-in Unit (Top View)



CH 2 Preamplifier

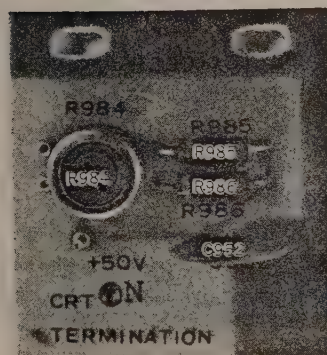


CH 1 Preamplifier

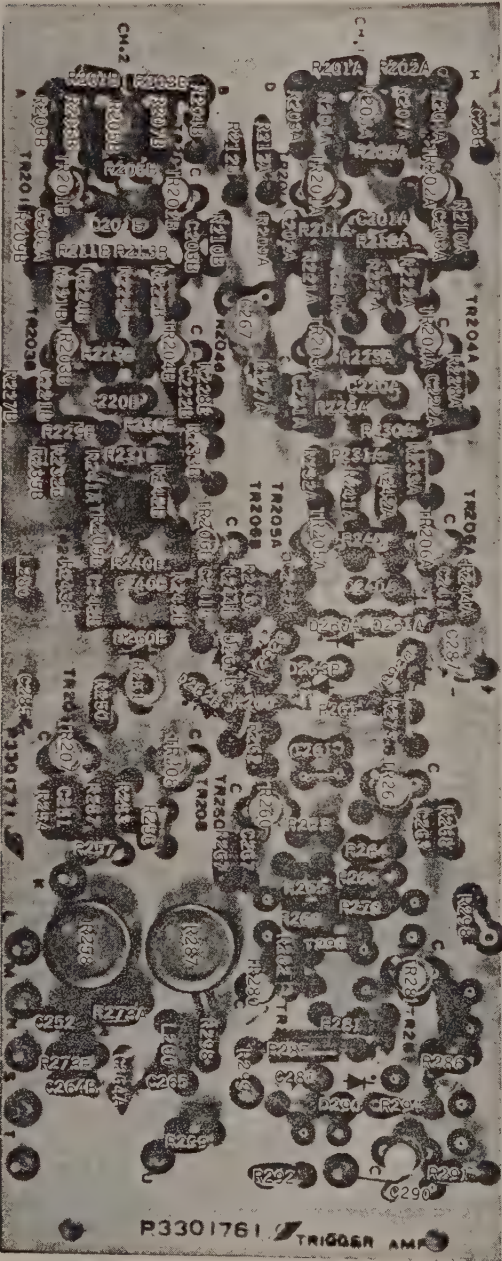
Vertical Main Amplifier

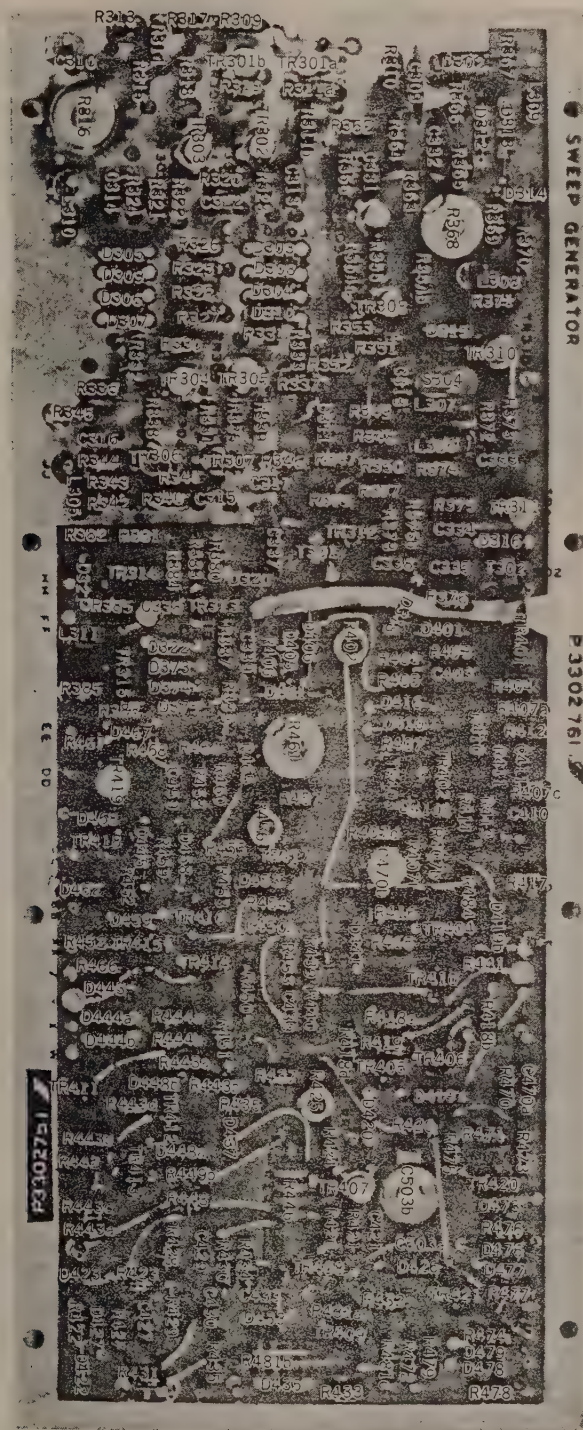


CRT Termination



Trigger Amplifier





SWEEP GENERATOR

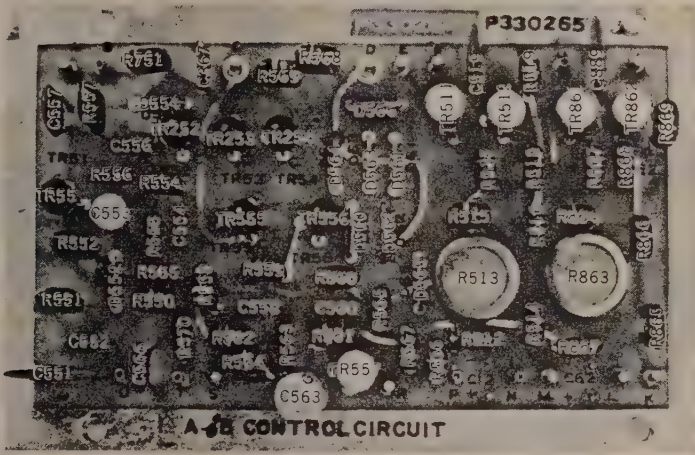
A Trigger Circuit

P 3302761

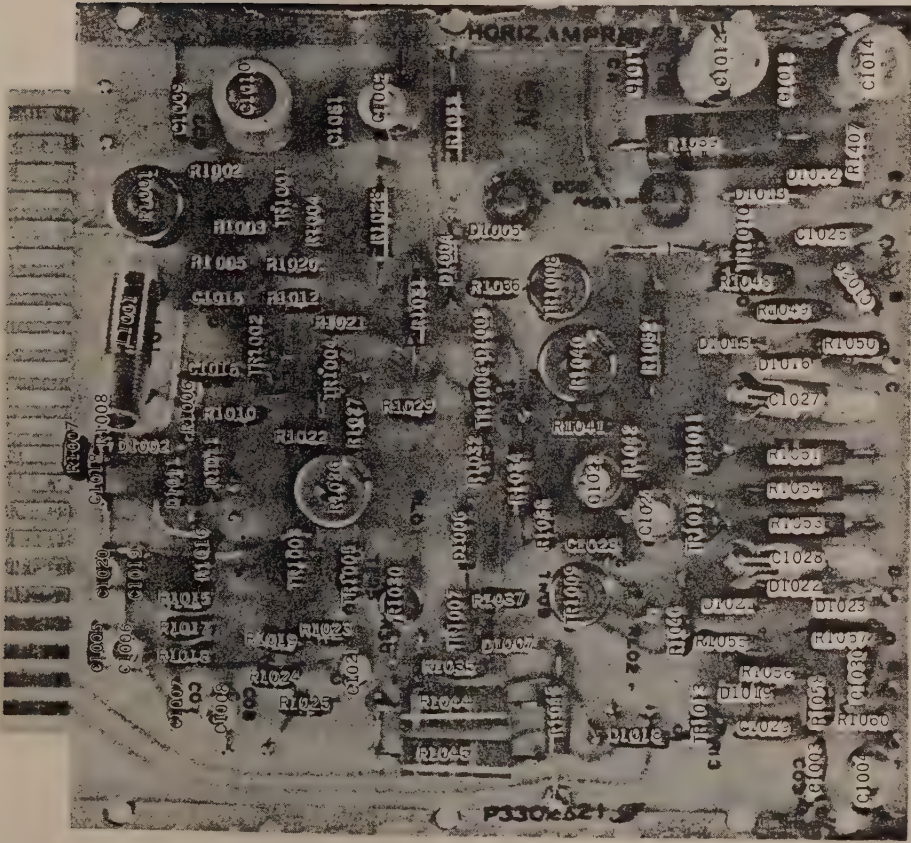
A Sweep Generator

B Sweep Generator

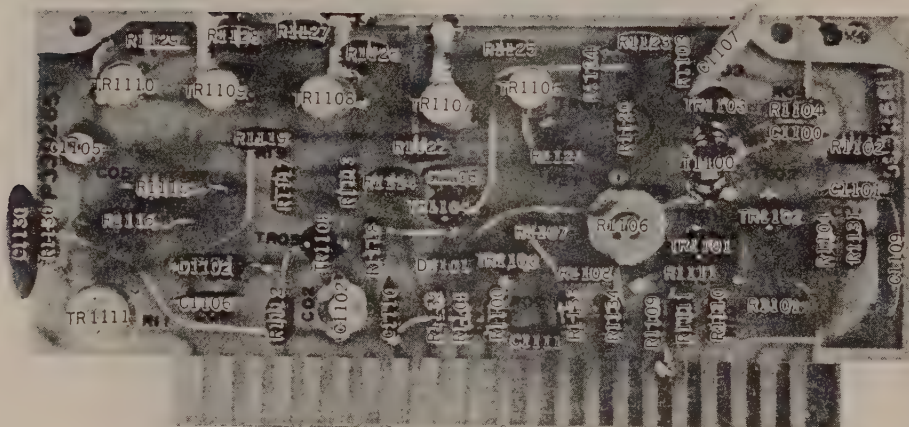
B Ends A Control Circuit



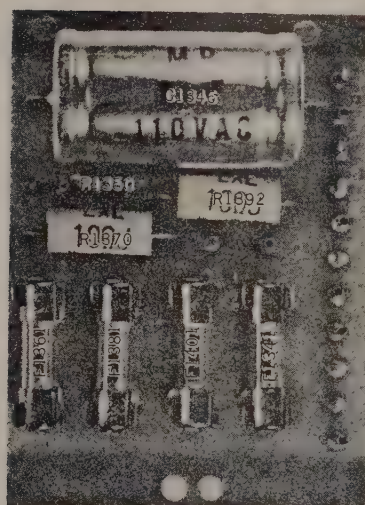
Horizontal Amplifier



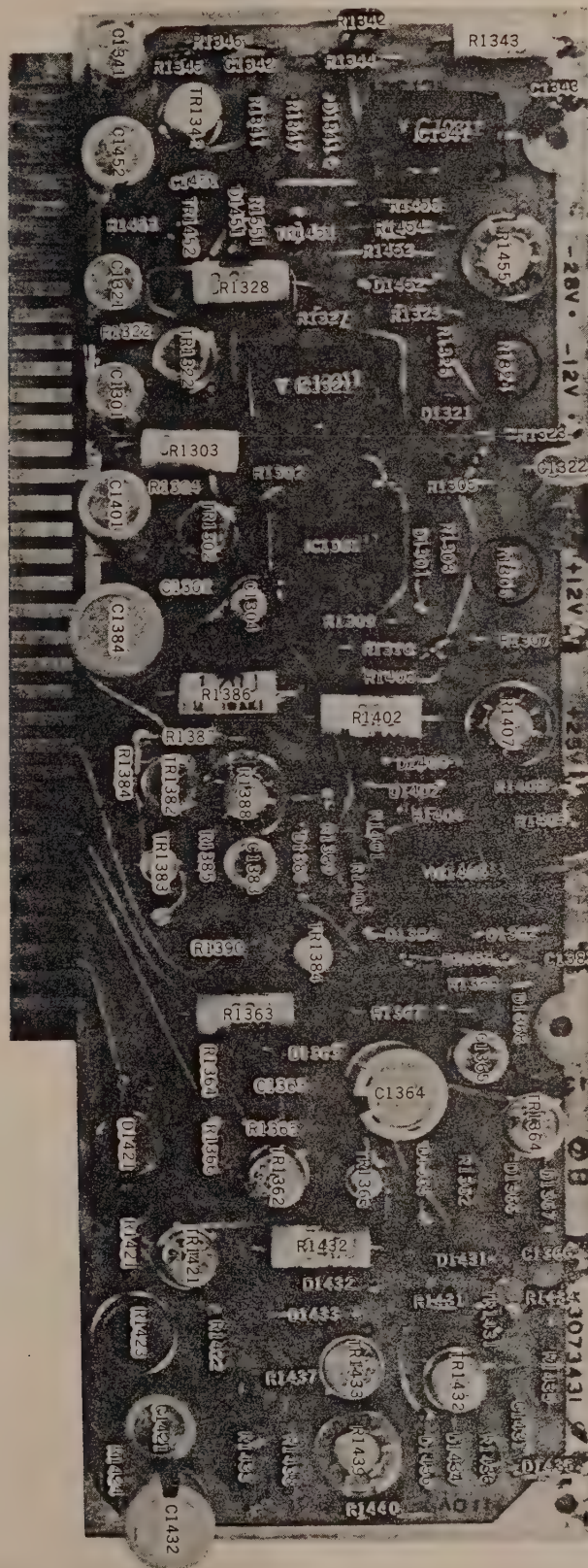
Z Amplifier



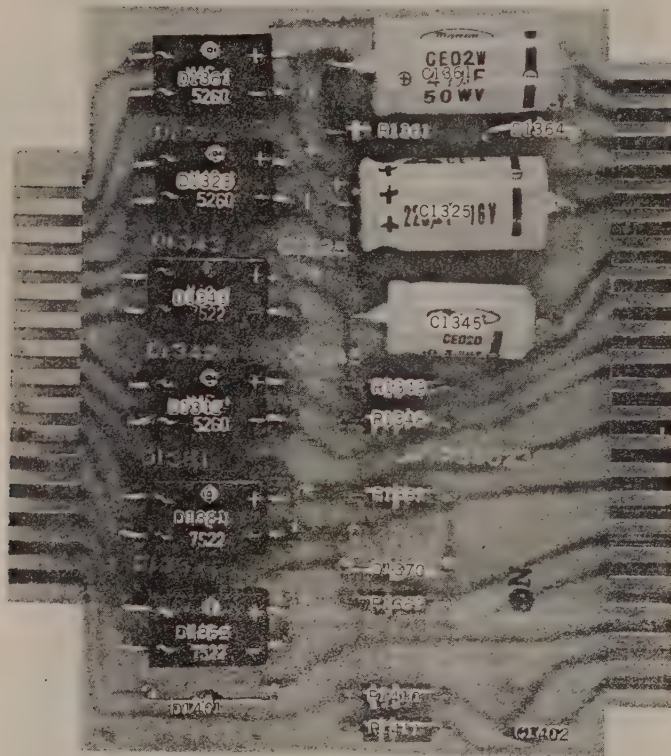
Low Voltage Power Circuit



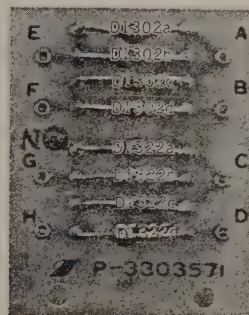
Low Voltage Power Circuit

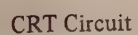


Low Voltage Power Source Rectifier Circuit

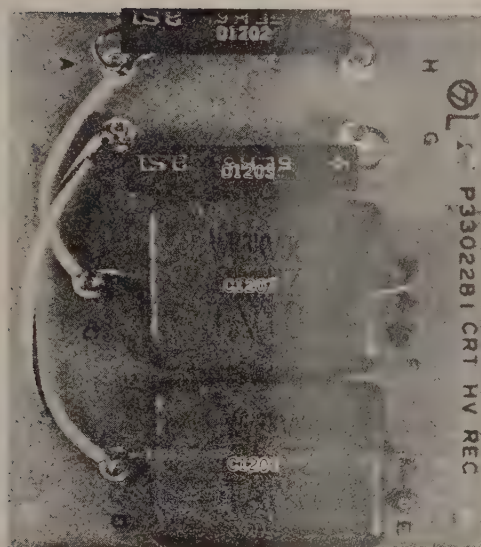


Low Voltage Power Source Rectifier Circuit



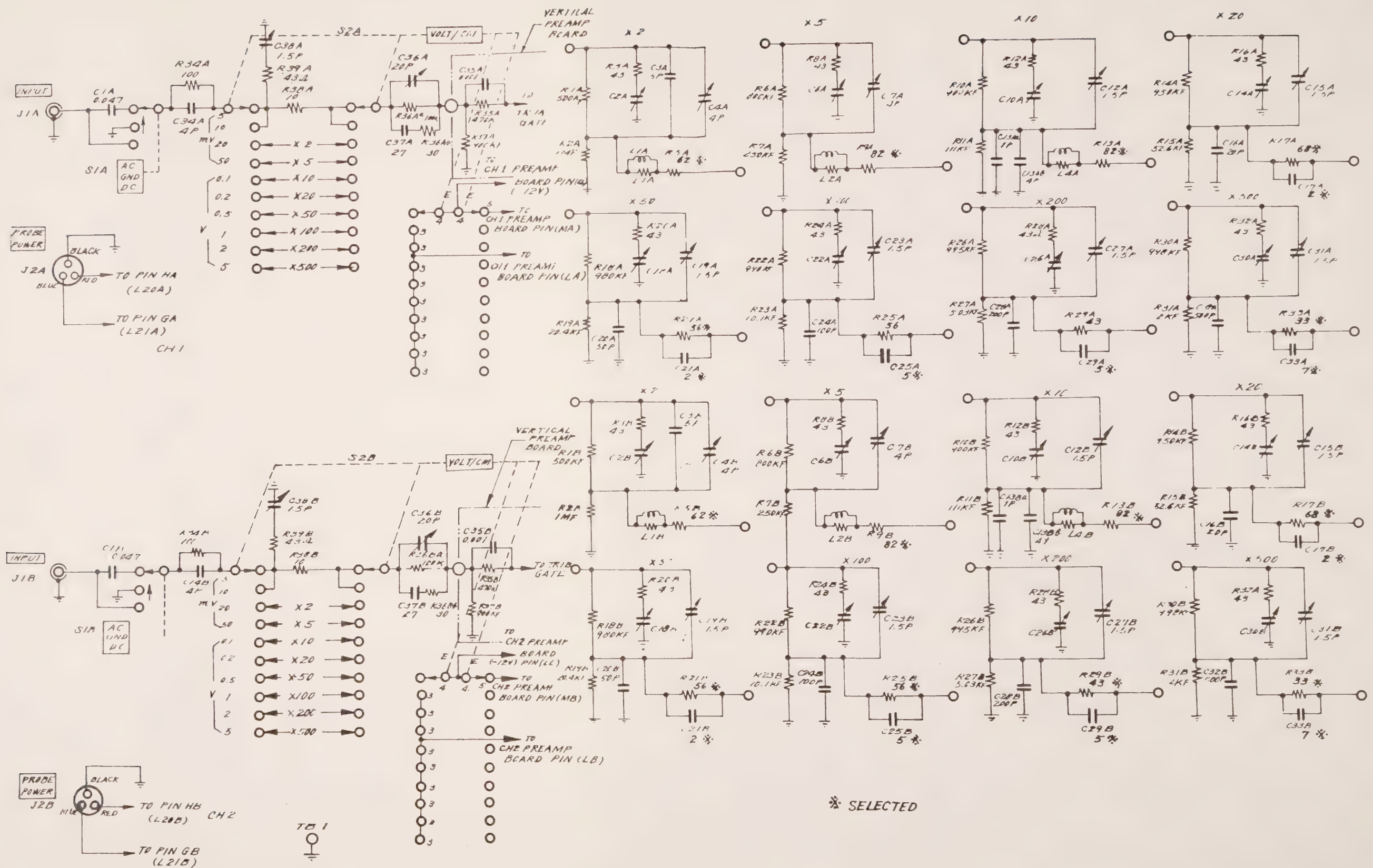


CRT Circuit (High Voltage Rectifier Circuit)



Calibration Voltage and Current Generating Circuit

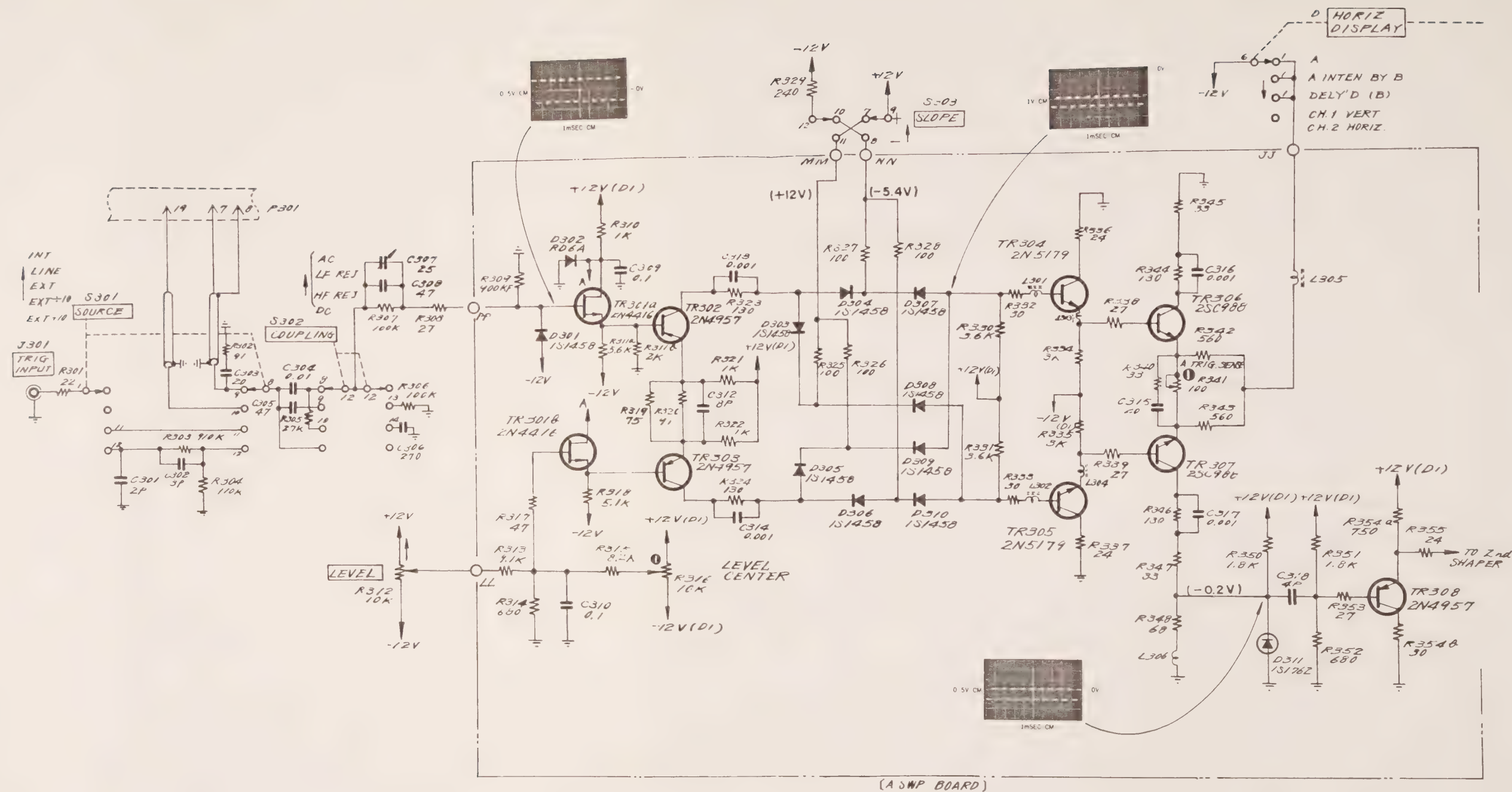




VERTICAL INPUT & ATTENUATOR

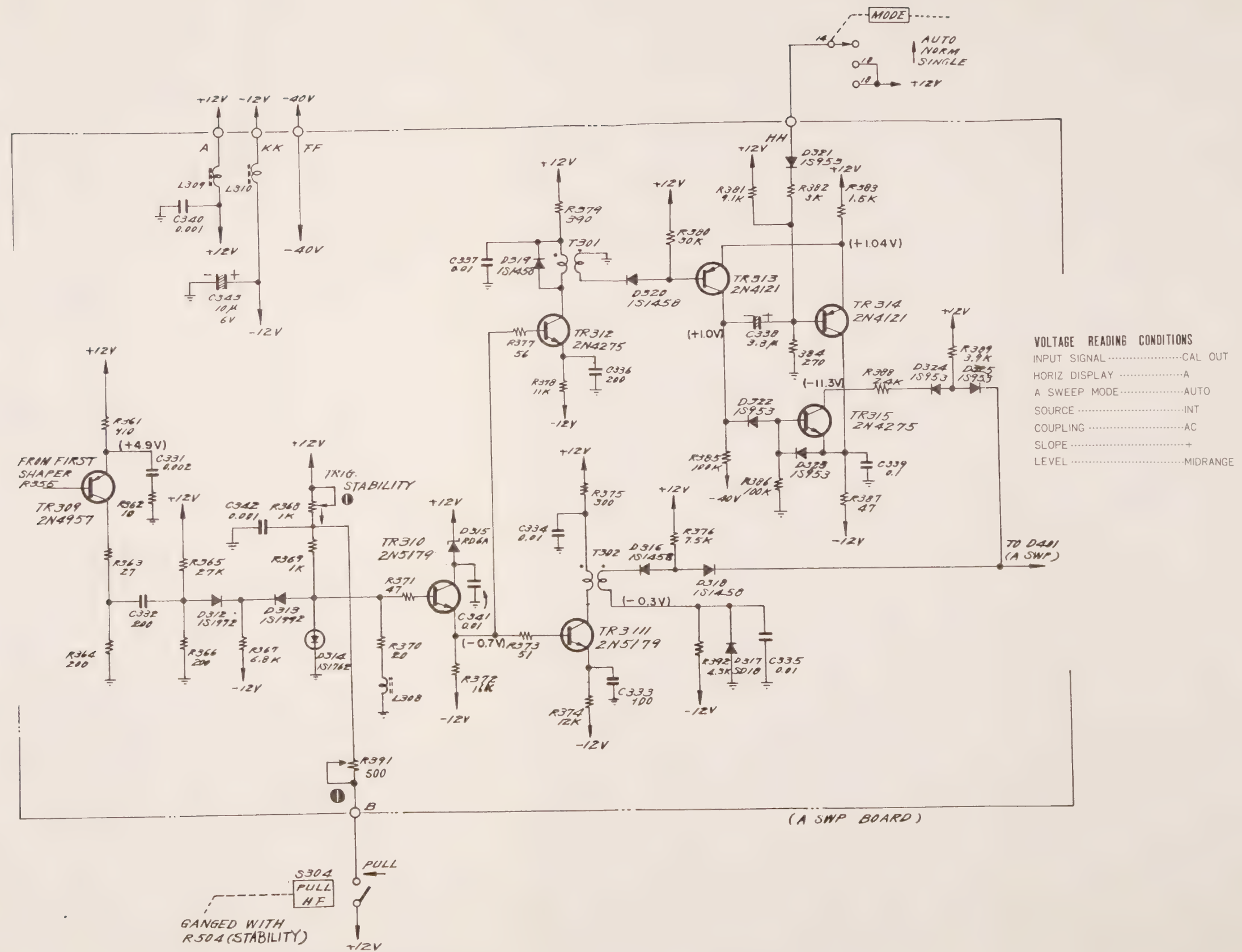
2N4416	R62B	R63B	K64B	R65B
RED	1K		200	
ORANGE	1K		220	
YELLOW	1K		240	
GREEN	910		240	



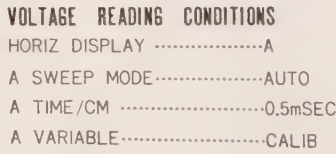


VOLTAGE & WAVEFORM READING CONDITIONS

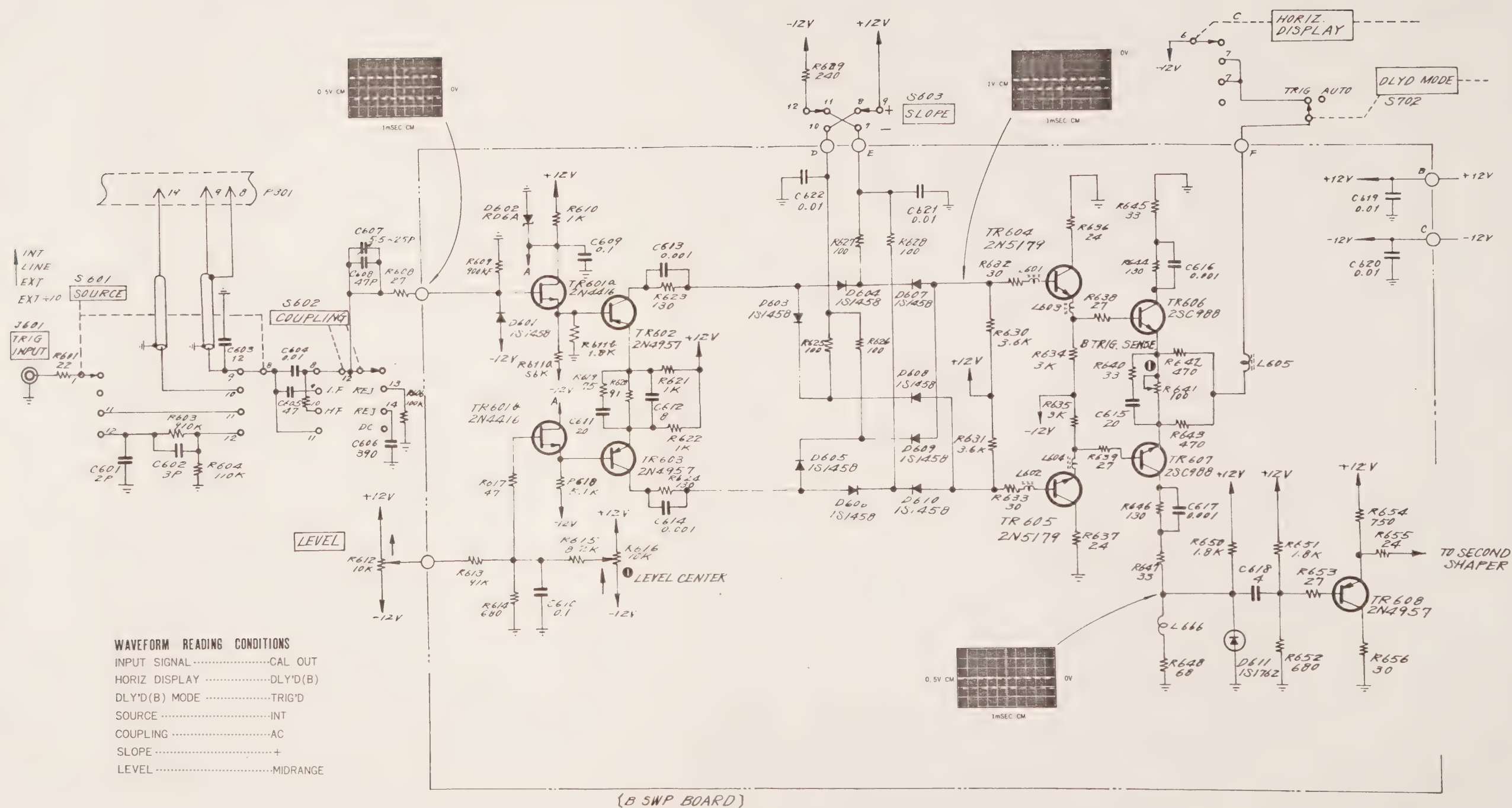
INPUT SIGNAL CAL OUT
 HORIZ DISPLAY A
 A SWEEP MODE AUTO
 SOURCE INT
 COUPLING AC
 SLOPE +
 LEVEL MIDRANGE

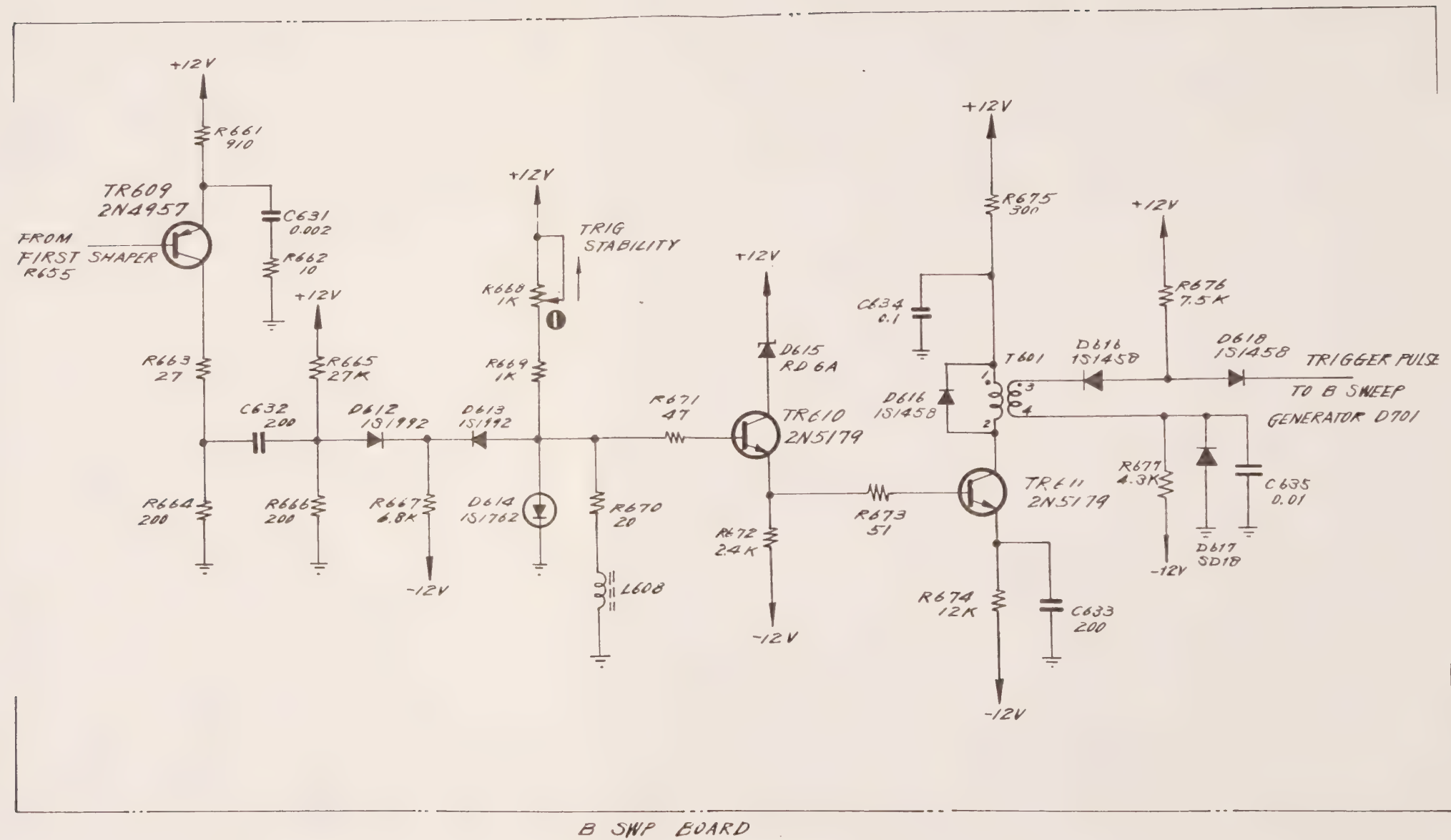


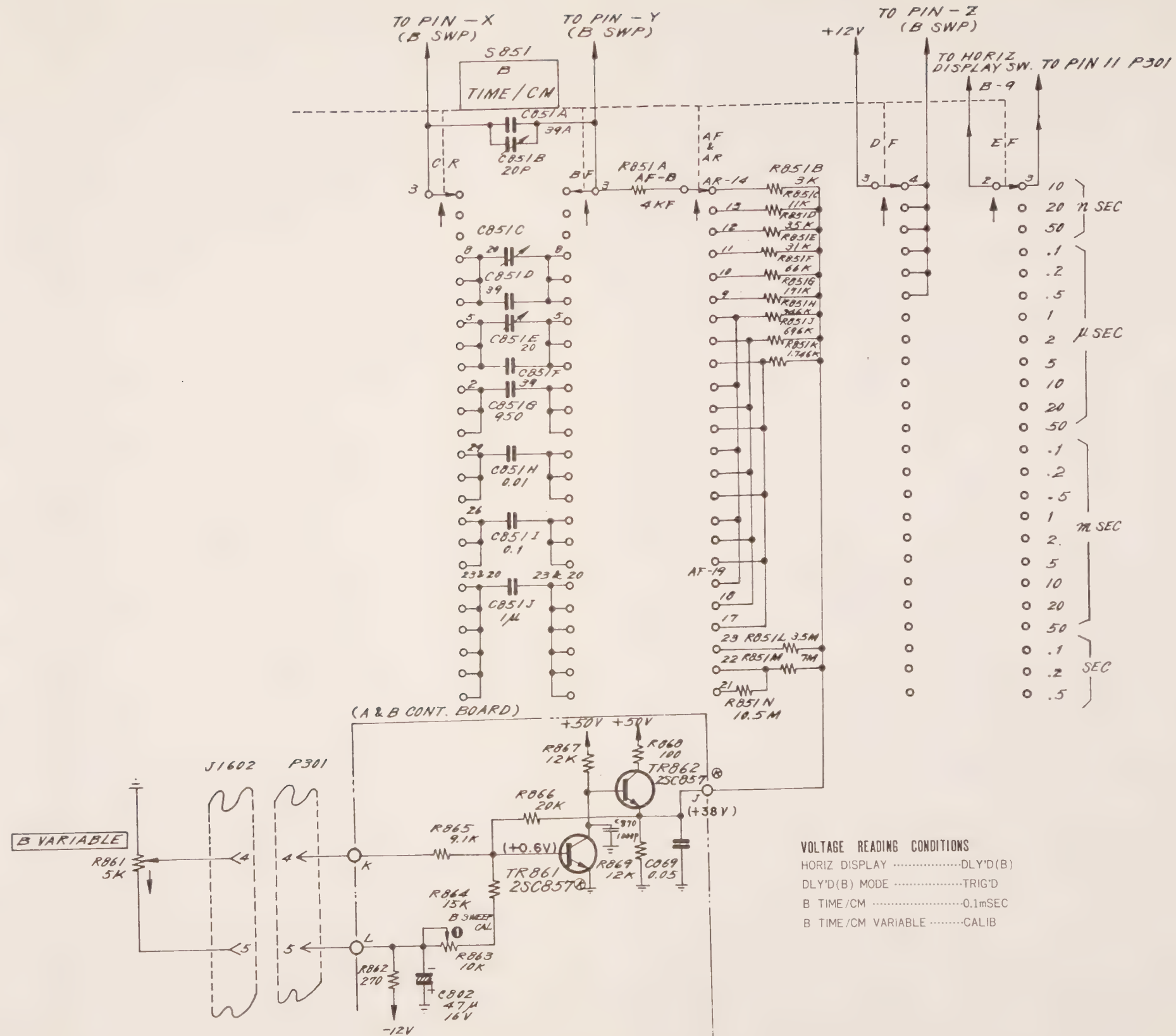
A TRIGGER GENERATOR SECOND SHAPER & AUTO MULTI

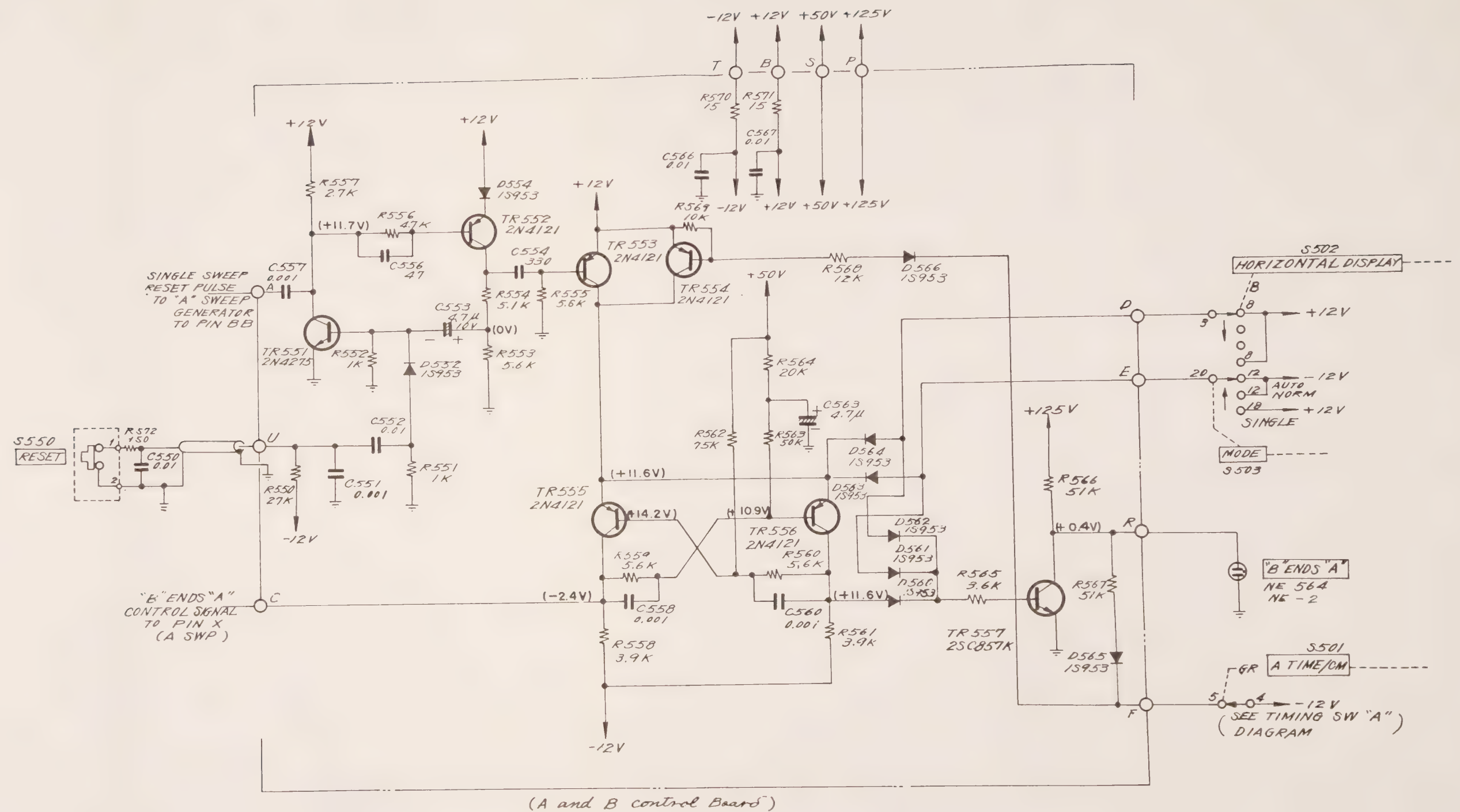


K - 605149-3

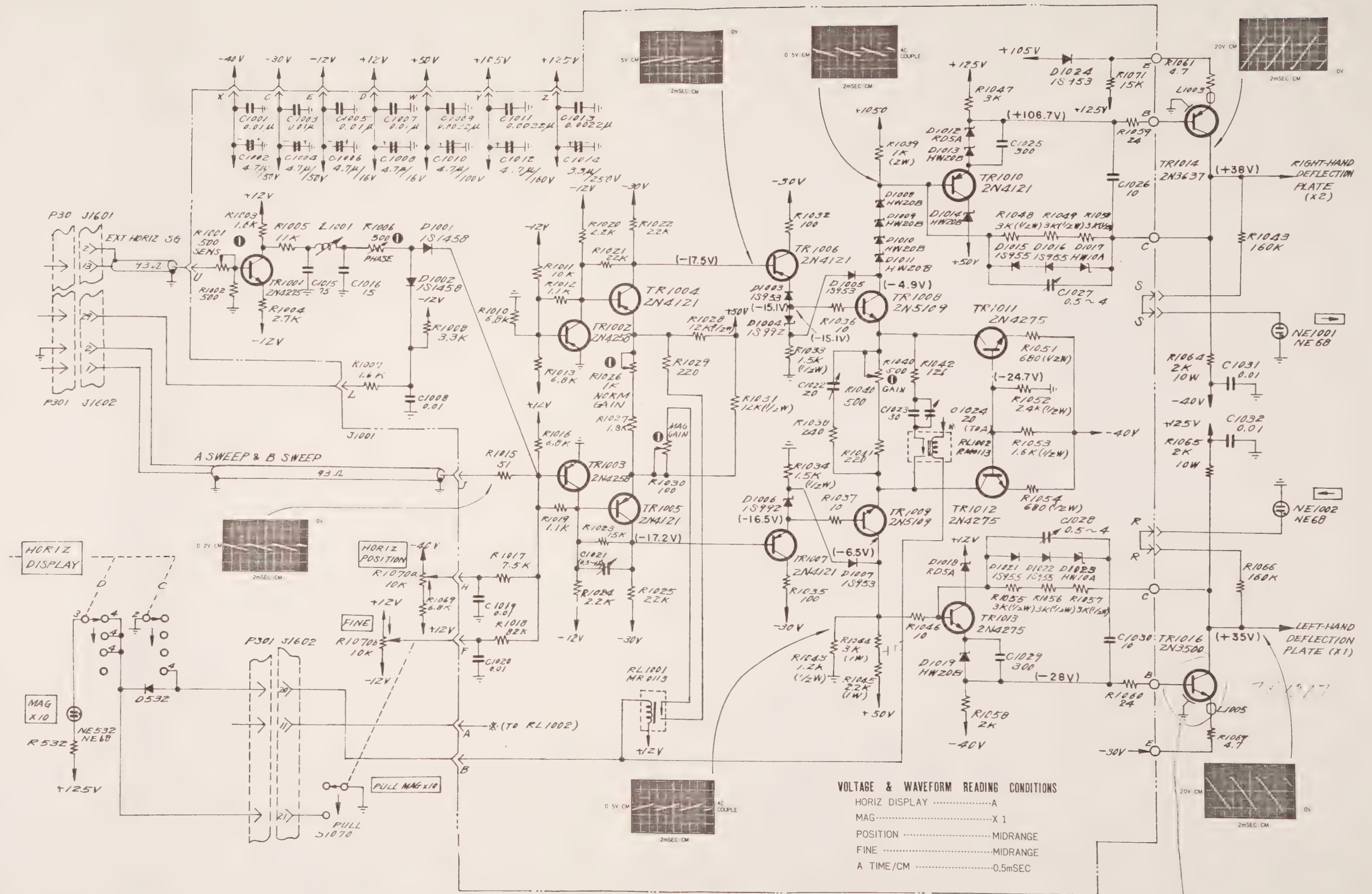


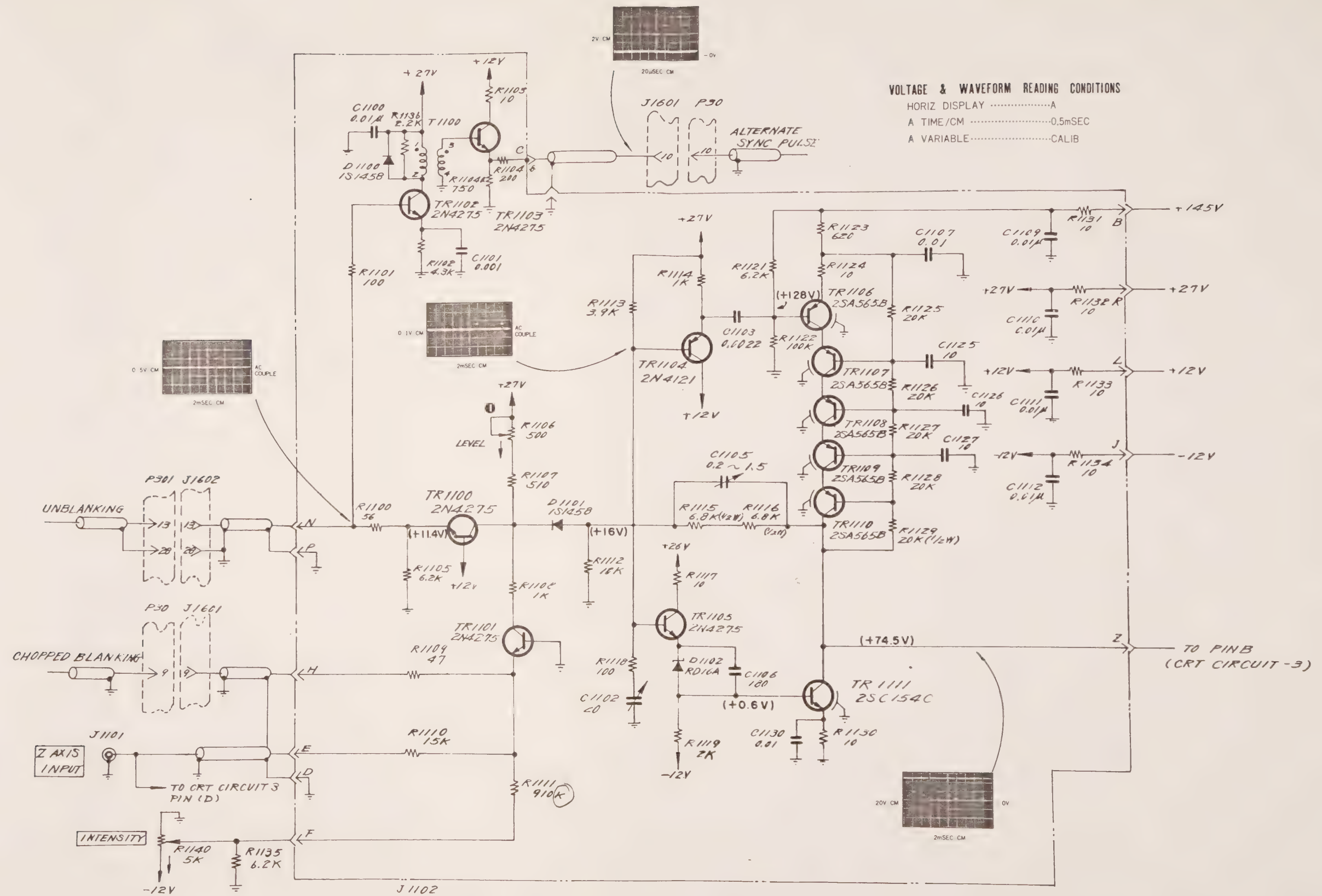


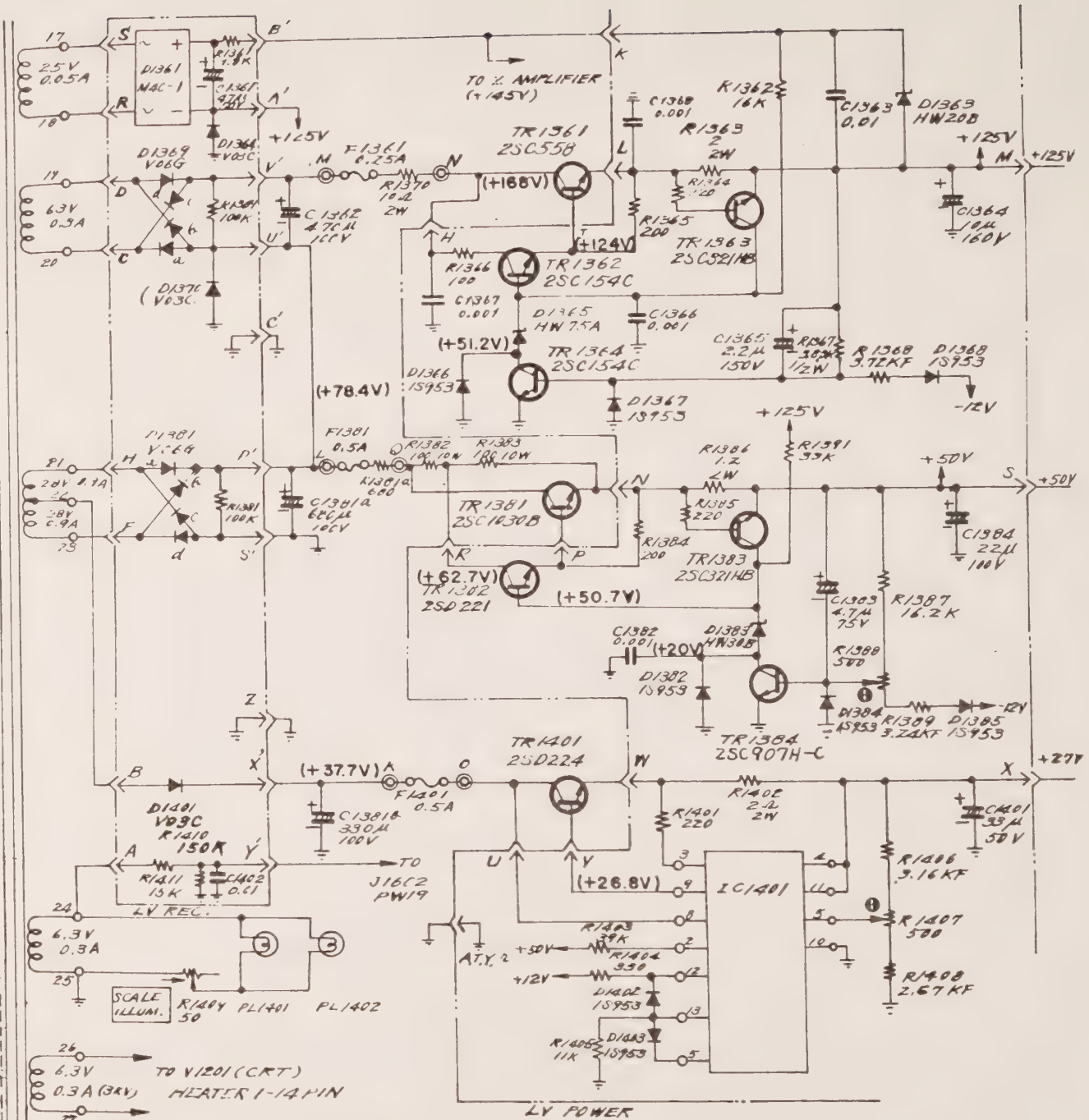
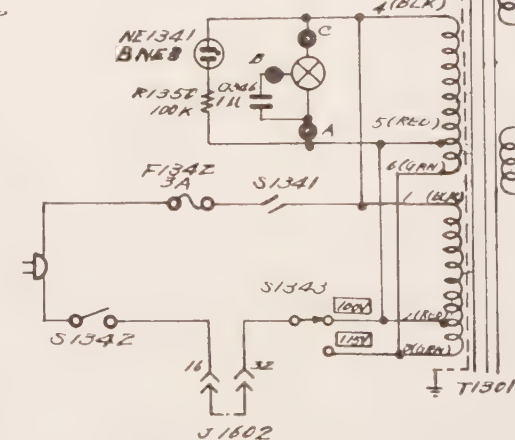
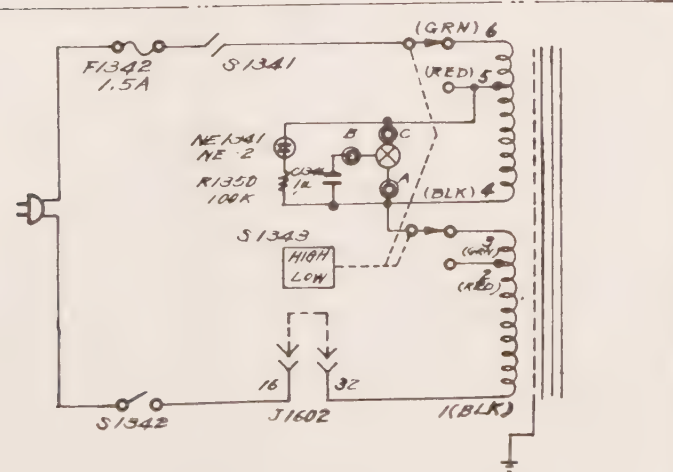
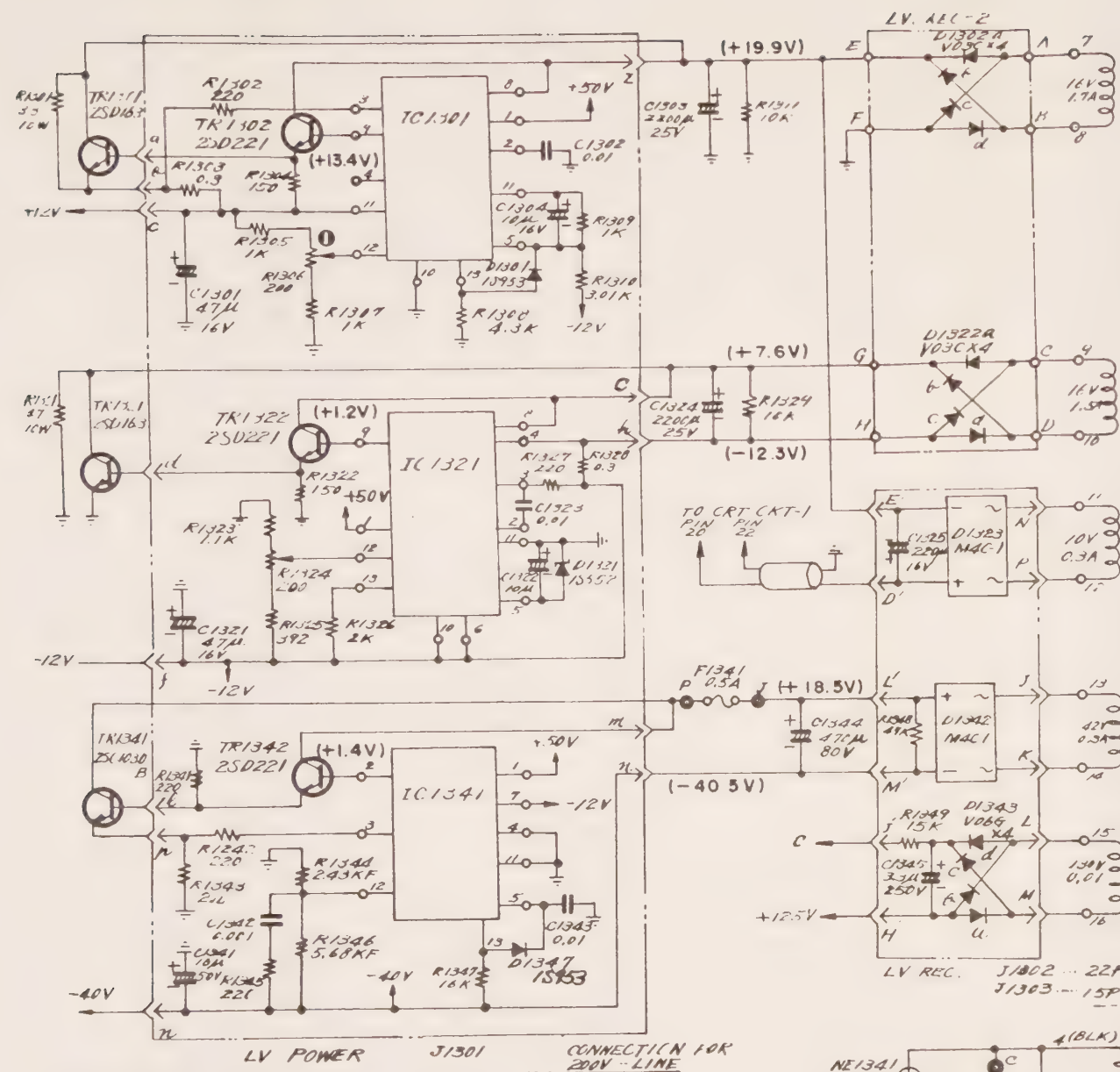




VOLTAGE READING CONDITIONS
 HOLIZ DISPLAY A INTEN BY B

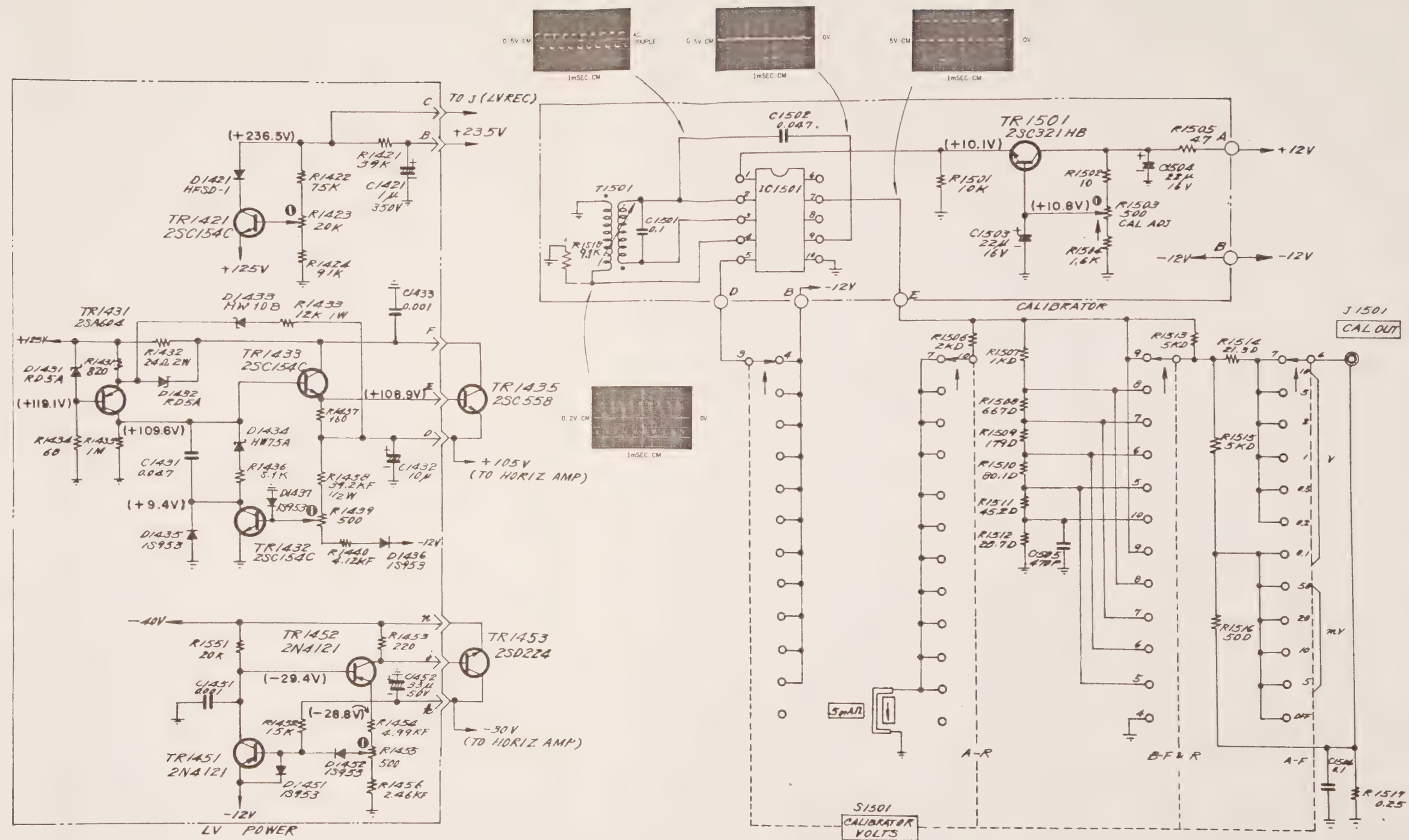


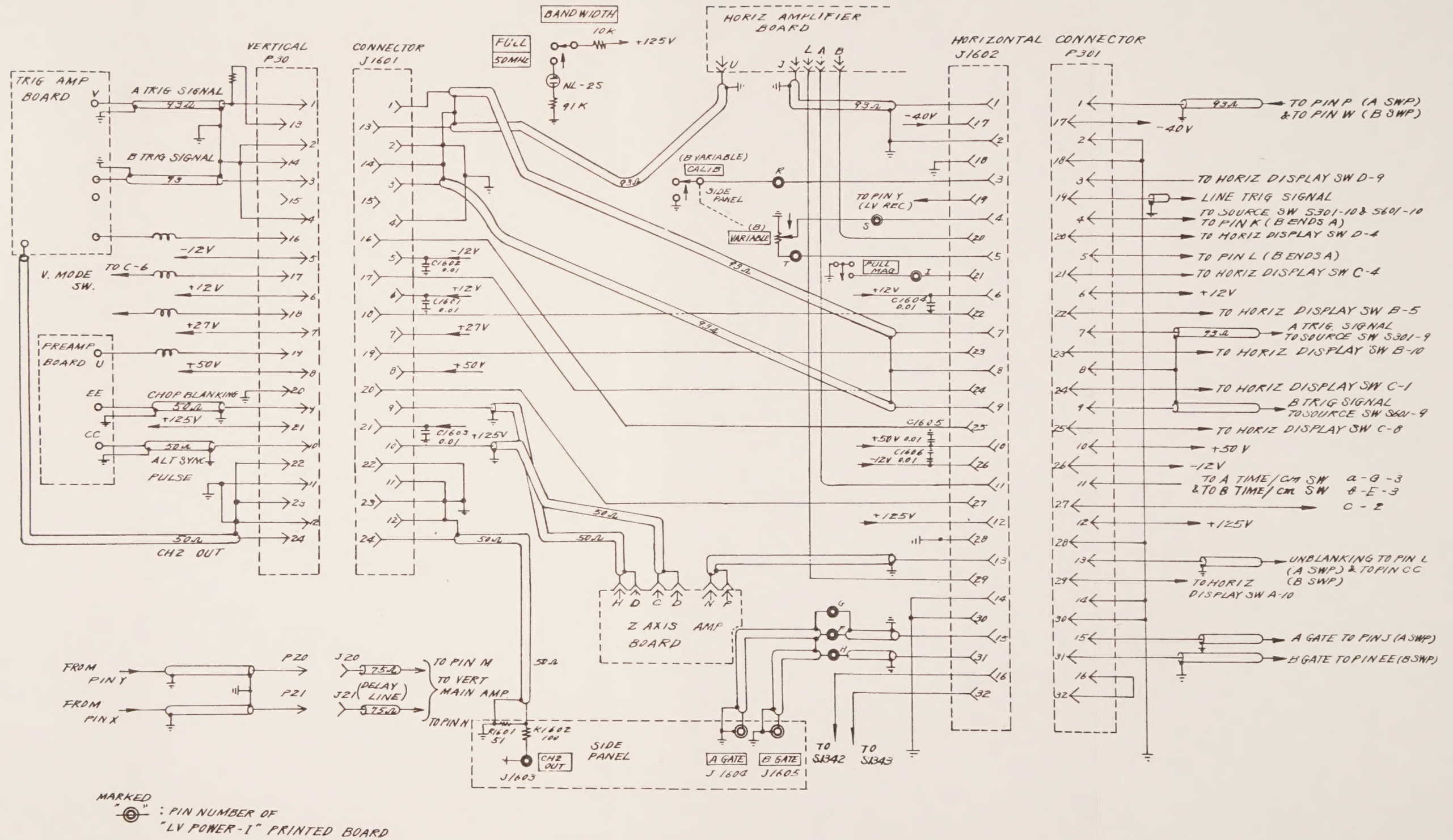


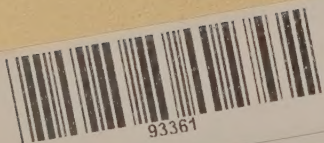


MARKED "P": PIN NUMBER OF "LV POWER-1" PRINTED BOARD

VOLTAGE READING CONDITIONS
LINE VOLTAGE AC 100V







93361